Mechanics

Level-III

Learning Guide-36

Unit of Competence: **Determine Welding Materials**

Module Title: **Determining Welding Materials**

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 1. Determine common engineering material

Instruction Sheet	Learning Guide #36

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Determining Common engineering material
- Ascertaining and understanding metallurgical principle
- The effects of different types of bonding in material
- Analyzing the effects of mechanical and thermal processes

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Determine common engineering materials according to standards.
- Ascertain and understand General metallurgical principles and properties of ferrous and non-ferrous metal in compliance with standards
- Identify and understand the effects of different types of bonding in materials with references to standards.
- Analyze the effects of mechanical and thermal processes on the principal properties of materials.

Learning Instructions:

1. Read the specific objectives of this Learning Guide.
2. Follow the instructions described below
3. Read the information written in the information "Sheet.
4. Accomplish the "Self-check
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation sheet

Information Sheet-1	Determining Common engineering material

1. Introduction

Materials are probably more deep-seated in our culture than most of us realize. Transportation, housing, clothing, communication, recreation, and food production—virtually every segment of our everyday lives is influenced to one degree or another by materials. Historically, the development and advancement of societies have been intimately tied to the members' ability to produce and manipulate materials to fill their needs. In fact, early civilizations have been designated by the level of their materials development (Stone Age, Bronze Age, and Iron Age).

The earliest humans had access to only a very limited number of materials, those that occur naturally: stone, wood, clay, skins, and so on. With time they discovered techniques for producing materials that had properties superior to those of the natural ones; these new materials included pottery and various metals. Furthermore, it was discovered that the properties of a material could be altered by heat treatments and by the addition of other substances. At this point, materials utilization was totally a selection process that involved deciding from a given, rather limited set of materials the one best suited for an application by virtue of its characteristics.

Characteristics that meet the needs of our modern and complex society; these include metals, plastics, glasses, and fibers. The development of many technologies that make our existence so comfortable has been intimately associated with the Accessibility of suitable materials. Advancement in the understanding of a material type is often the forerunner to the stepwise progression of a technology. devices rely on components that are made from what are called semiconducting materials. For instant, computer, integrated circuit, solar cells, optical fibers and so on are more products of materials which are composite of different materials together to form one stable material with special property for special purpose.

1.1. Solar Cells:

The space shuttle has deployed a number of satellites that functions as communication stations and scientific instruments. Satellites must function for years if they are to be cost effective. Batteries do not last long enough for satellite use, and fuel cells are unreliable. Solar panels have been found to be the only economic power source for satellites. The solar panels used on satellites are composed of many thousands of solar cells. When the intense sunlight in space hits the solar cells, electricity is generated. The solar cells are also known as a photovoltaic cell, changes radiation into electricity by taking advantage of the properties of semiconductors. A solar cell is a thin wafer (disk) of pure silicon (Si 14) doped (add impurities to(a semiconductor) in order to produce or modify its properties) with arsenic (As 33) to render it an n-type semiconductor. In the other layer of the wafer, silicon doped with other material for example boron (B 5) to produces p-type semiconductor. Then, one electric lead is attached with the wafer layer with n-type and other lead is attached with the p-type layer. When the sunlight strikes the solar cell, electrons flow from the surface layer to the body of the cell. The electrons moving through the leads create an electric current. Many kinds of materials are used to make solar cell. Some solar cells employs layers of silicon dioxide (SiO_2) and thin films of Chromium, Copper, Silver, Gold, or Aluminum over the n-type or p-type silicon layers.

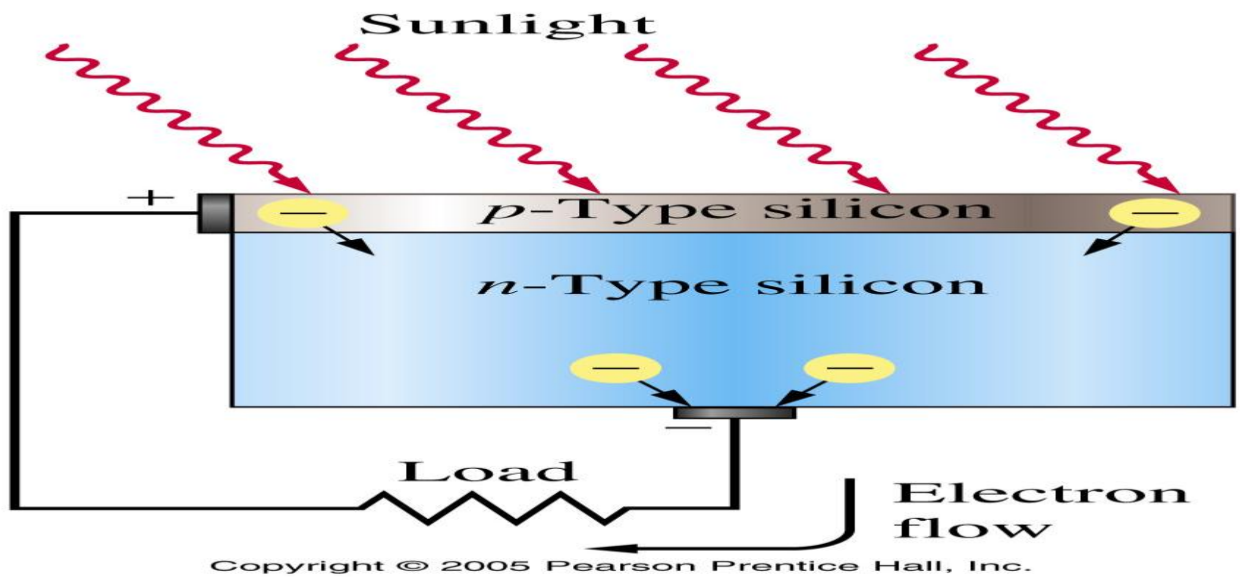


Figure 1.Solar Cell

1.2. ***Determining Common engineering materials***

This understanding of the materials resources and nature enable the engineers to select the most appropriate materials and to use them with greatest efficiency in minimum quantities whilst causing minimum pollution in their extraction, refinement and manufacture.

1.3. Classification of materials

Almost every substance known to man has found its way into the engineering workshop at some time or other. The most convenient way to study the properties and uses of engineering materials is to classify them into 'families' as shown in figure below

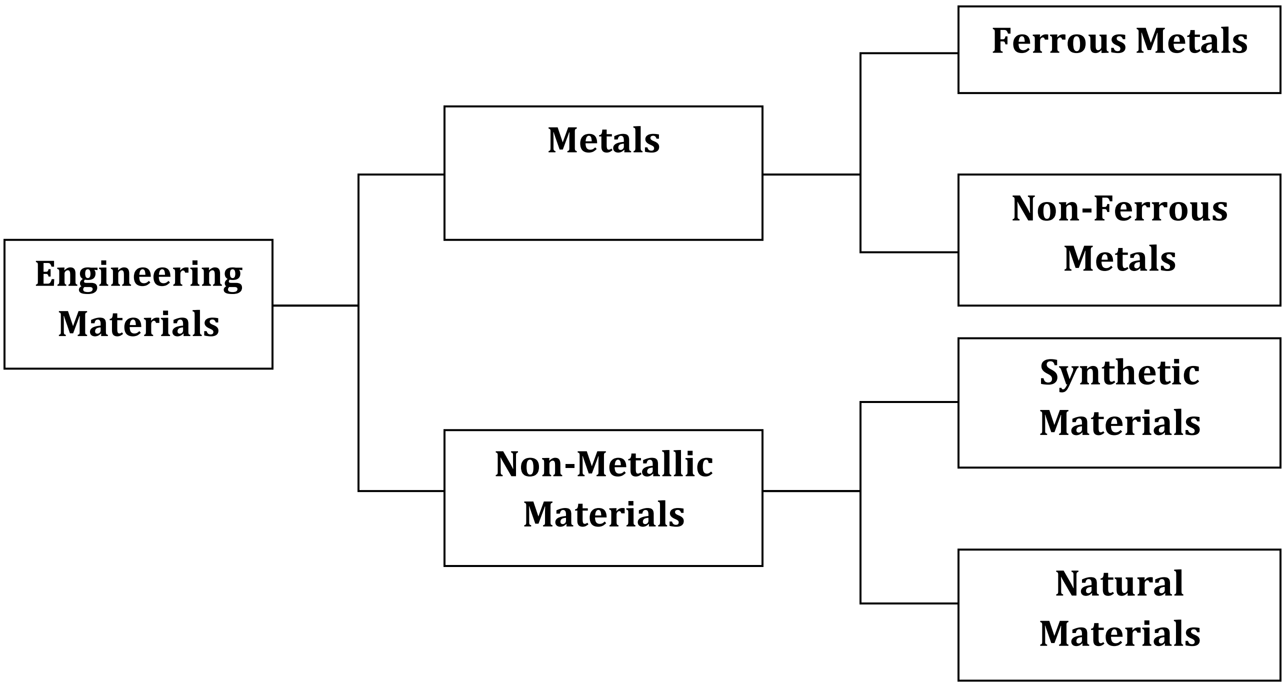


Figure .2 Classifications of engineering materials

1.3.1 Metals ferrous metals

- These are metals and alloys containing a high proportion of the element iron.
- They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.
- As an example of ferrous metals such as: bridge building, the structure of large buildings, railway lines, locomotives and rolling stock and the bodies and highly stressed engine parts of road vehicles.
- The ferrous metals themselves can also be classified into "families", and these are shown in figure 3.

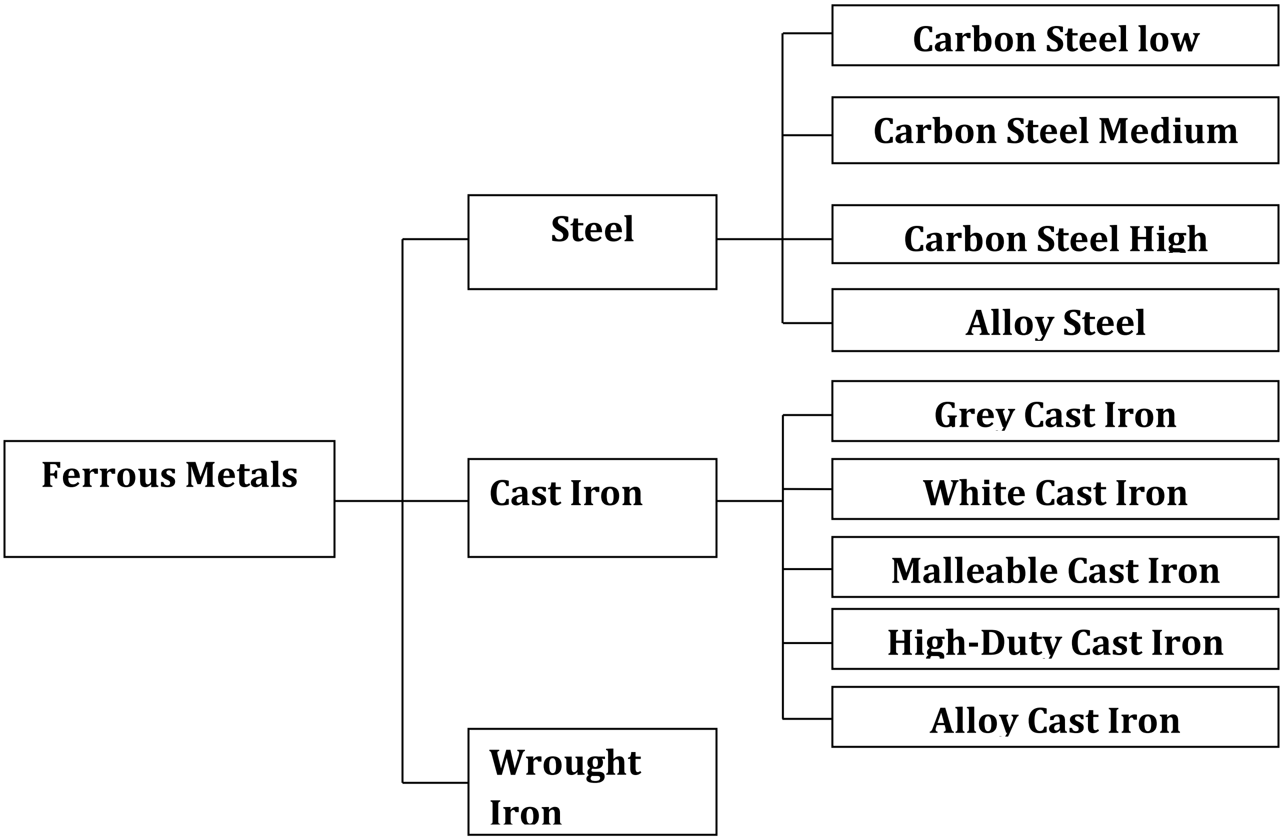


Figure. 3 Classifications of Ferrous Materials

1.3.2 -Non – ferrous metal

These materials refer to the remaining metals known to mankind.

- The pure metals are rarely used as structural materials as they lack mechanical strength.
- They are used where their special properties such as corrosion resistance, electrical conductivity and thermal conductivity are required. Copper and aluminum are used as electrical conductors and, together with sheet zinc and sheet lead, are use as roofing materials.
- They are mainly used with other metals to improve their strength.

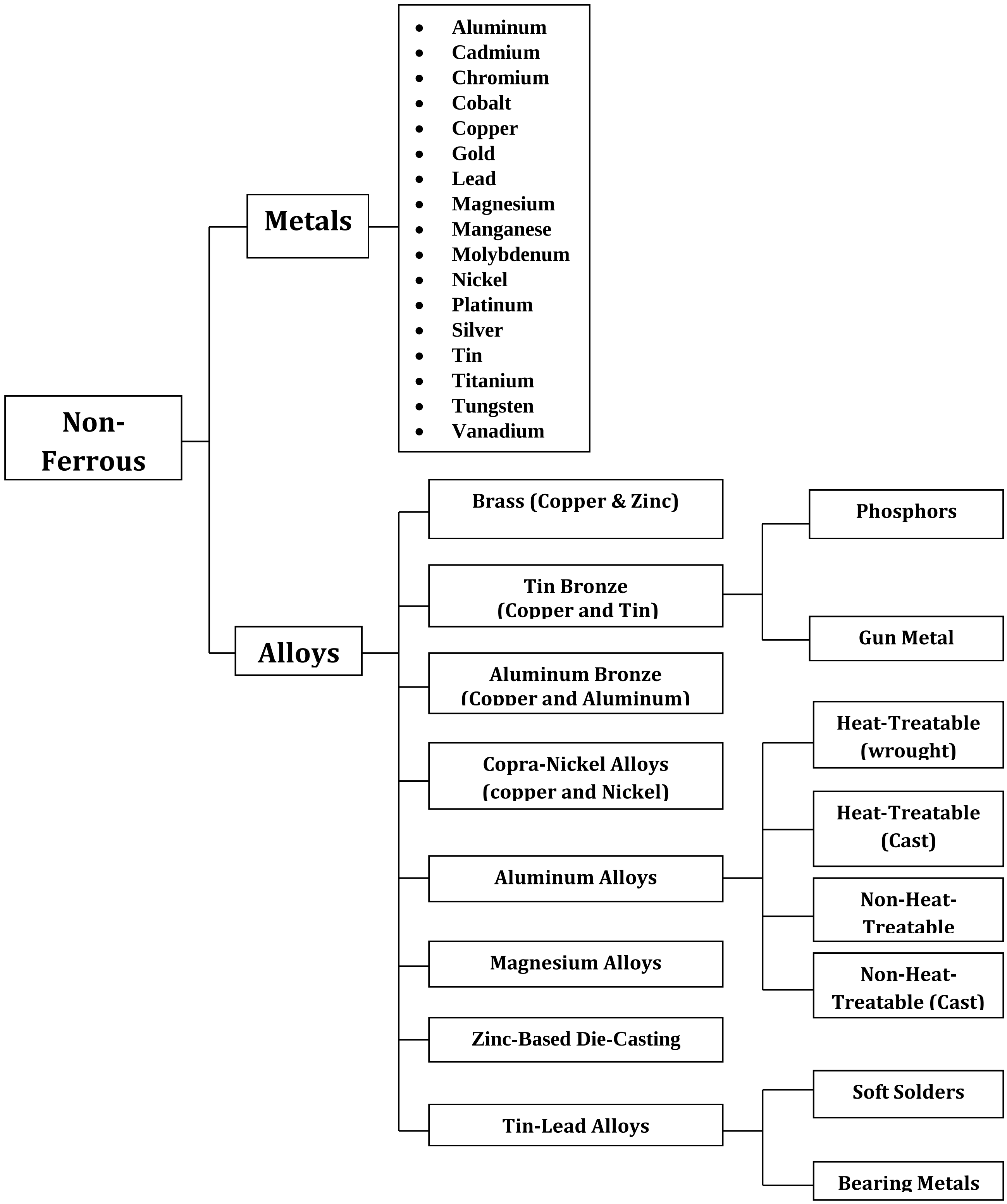


Figure 4: Classifications of Non-Ferrous Materials

1.4 Basic metal identification

When you are selecting a metal to use in fabrication, to perform a mechanical repair, or even to determine if the metal is wieldable, you must be able to identify its basic type.
A number of field identification methods can be used to identify a piece of metal. Some common methods are surface appearance, spark test, chip test, magnet test, and occasionally a hardness test.

Surface Appearance

Sometimes you can identify a metal simply by its surface appearance. *Table 1-1* indicates the surface colours of some of the more common metals As you can see by studying the table, a metal's surface appearance can help you identify it, and if you are unsure, you can obtain further information by studying a fresh filing or a fresh fracture. If a surface examination does not provide you with enough information for a positive identification, it should give you enough information to place the metal into a class.
In addition to the colour of the metal, distinctive marks left from manufacturing also help in determining the identity of the metal.

- Cast iron and malleable iron usually show evidence of the sand mould.
- Low-carbon steel often shows forging marks.
- High-carbon steel shows either forging or rolling marks.

Inspecting the surface texture by feel may also provide another clue to its identity.

- Stainless steel, in the unfinished state, is slightly rough.
- Wrought iron, copper, brass, bronze, nickel, and Monel are smooth.
- Lead is smooth but has a velvety appearance.

When visual clues from surface appearance; filings, fractures, manufacturing marks, or textural clues from the feel of the surfaces, do not give enough information to allow positive identification, other tests become necessary.
Some are complicated and require equipment Seabees do not usually have. However, the following are a few additional simple tests, which are reliable when done by a skilled person: spark test, chip test, magnetic tests, and hardness

- **PIG IRON**

All iron and steel products are derived originally from pig iron. This is the raw material obtained from the chemical reduction of iron ore in a blast furnace. The process of reduction of iron ore to pig iron is known as SMELTING. Pig Iron partly refined in a copula furnace produces various grades of Cast Iron. By peddling or shorting processes, wrought iron is produced from pig iron. Steel is produced from pig iron by various steel making processes, such as Bessemer converter, Open-hearth Furnace, Oxygen Processes, Electric and Spray steel making furnace

- ***Iron* Ore**

Iron ore are generally carbonates, hydrates or oxides of the metals. The common types of iron ores are tabulated as shown in table 1 below:

Table 1: iron ore composition

ORE	*Composition*	*Form*	*% of Metal*
Red hematite	Fe2O3	Oxide	60-70
Magnetite	Fe3O4	Oxide	62-72
Limonite	Fe3O3H2O	Oxide	40-60
Iron Pyrite	FeS2	Sulfide	30-40
Iron Stone(Siderite)	FeCO3	Carbonate	35-50

Ferrous metals

These are metals and alloys containing a high proportion of the element iron.

- They are the strongest materials available and are used for applications where high strength is required at relatively low cost and where weight is not of primary importance.
- As an example of ferrous metals such as: bridge building, the structure of large buildings, railway lines, locomotives and rolling stock and the bodies and highly stressed engine parts of road vehicles. The ferrous metals themselves can also be classified into “families”, and these are shown in figure 3

1.1.6 Non – metallic materials (synthetic materials)

These are non – metallic materials that do not exist in nature, although they are manufactured from natural substances such as oil, coal and clay. Some typical examples are classified as shown in figure 6

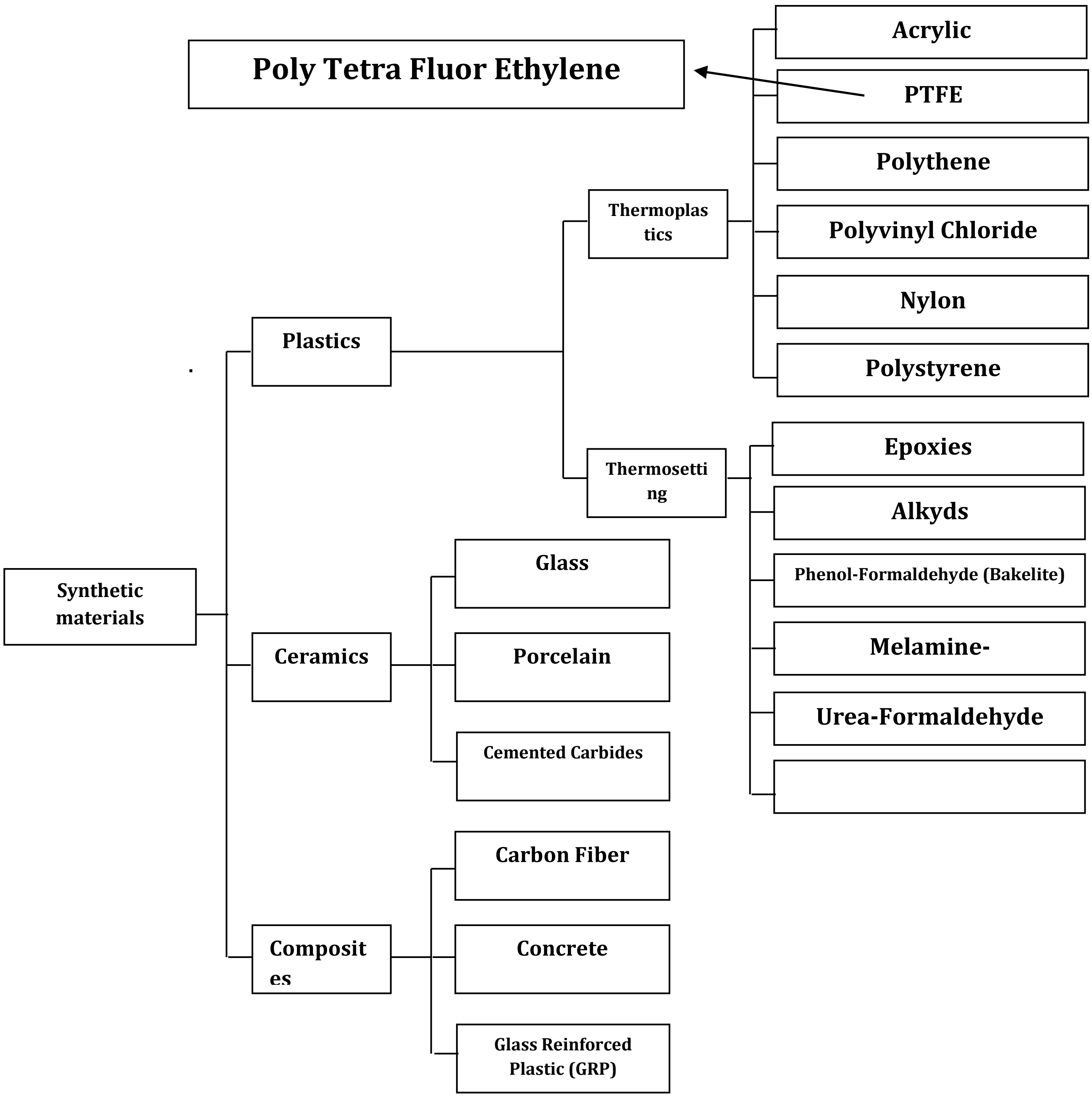


Figure 6. Classifications of synthetic material

- ## Composite materials (composites)

These are materials made up from, or composed of, a combination of different materials to take overall advantage of their different properties. In man-made composites, the advantages of deliberately combining materials in order to obtain improved or modified properties were understood by ancient civilizations. An example of this was the reinforcement of air-dried bricks by mixing the clay with straw. This helped to reduce cracking caused by shrinkage stresses as the clay dried out. In more recent times, horse hair was used to reinforce the plaster used on the walls and ceiling of buildings. Again this was to reduce the onset of drying cracks. Nowadays, especially with the growth of the plastics industry and the development of high-strength fibers, a vast range combination of materials is available for use in composites. For example, carbon fiber reinforced frames for tennis rackets and shafts for golf clubs have revolutionized these sports

Non – metallic (Natural materials)

Such materials are so diverse that only a few can be listed here to give a basic introduction to some typical applications.

- **Wood:** This is naturally occurring fibrous composite material used for the manufacture of casting patterns.
- **Rubber:** This is used for hydraulic and compressed air hoses and oil seals. Naturally occurring latex is too soft for most engineering uses but it is used widely for vehicle tires when it is compounded with carbon black.
- **Glass:** This is a hardwearing, abrasion-resistant material with excellent weathering properties. It is used for electrical insulators, laboratory equipment, optical components in measuring instruments etc and, in the form of fibers, is used to reinforce plastics. It is made by melting together the naturally occurring materials: silica (sand), limestone (calcium carbonate) and soda (sodium carbonate).
- **Emery:** This is a widely used abrasive and is a naturally occurring aluminum oxide. Nowadays it is produced synthetically to maintain uniform quality and performance.
- **Ceramic:** These are produced by baking naturally occurring clay sat high temperatures after molding to shape. They are used for high – voltage insulators and high – temperature – resistant cutting tool tips.

- high speeds for metal finishing where surface finish is greater importance. For example, internal combustion engine pistons and bearings. They are also used for dressing grinding wheels.
- **Oils:** Used as bearing lubricants, cutting fluids and fuels.
- **Silicon:** This is used as an alloying element and also for the manufacture of semiconductor devices.

Self-Check- 1	Written Test

Direction-Choose the best answer

1. These are metals and alloys contain a high proportion of the element iron.
   a Magnetite
   b Hematite
   c Limonite
   d Ferrous metal
2. All iron and steel products are derived originally from
   a. Cast iron
   b. steel
   c. pig iron
   d. None
3. These are mainly used with other metals to improve their strength.
   a. Gray cast iron
   b. White cast iron
   c. Ductile cast iron
   d. None ferrous metal
4. This is used as an alloying element and also for the manufacture of semiconductor devices.
   a. sodium
   b. calcium
   c. silicon
   d .None

Answer Sheet

Score = ____________

Rating:

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet-2	Ascertaining and understanding metallurgical principles

1. Materials Engineering Principles

The principal function of metallurgical elements is to improve its properties. Thus they may be added to improve mechanical properties. They may be used to enhance resistance to corrosion or high temperature oxidation. Further, they may be present to develop special characteristics such as those of an electrical or magnetic nature, strength at high temperatures or for the steel to remain austenitic at room temperatures.

The alloying elements added may either simply dissolve in the ferrite or they may combine with some of the carbon, forming carbides. The principal effects which these alloying elements have on the microstructure and properties of steel include those on the allotropic transformation temperatures.

1.1. Selection of Materials for Engineering Purposes

The selection of a proper material, for engineering purposes, is one of the most difficult problems for the designer. The best material is one which serve the desired objective at the minimum cost. The following factors should be considered while selecting the material:

- Availability of the materials,
- Suitability of the materials for the working conditions in service, and *A filament of bulb needs a material like tungsten which can withstand high temperatures without undergoing deformation.*
- The cost of the materials. The important properties, which determine the utility of the material, are physical, chemical and mechanical properties. We shall now discuss the physical and mechanical properties of the material in the following articles.

1.2. Properties of engineering Materials

1.2.1. Physical Properties

The important physical properties of the metals are density, color, size and shape (dimensions), specific gravity, porosity, luster etc. Some of them are defined as under

- **Density**

Mass per unit volume is called as density. In metric system its unit is kg/mm3. Because of very low density, aluminum and magnesium are preferred in aeronautic and transportation applications.

- **Color is deals the quality of light reflected from the surface of metal.**
- **Size and shape**

Dimensions of any metal reflect the size and shape of the material. Length, width, height, depth, curvature diameter etc. determines the size. Shape specifies the rectangular, square, circular or any other section.

- **Specific Gravity**

Specific gravity of any metal is the ratio of the mass of a given volume of the metal to the mass of the same volume of water at a specified temperature.

- **Porosity**

A material is called as porous or permeable if it has pores within it.

- **Chemical Properties**

The study of chemical properties of materials is necessary because most of the engineering materials, when they come in contact with other substances with which they can react, suffer from chemical deterioration of the surface of the metal. Some of the chemical properties of the metals are corrosion resistance, chemical composition and acidity or alkalinity. Corrosion is the gradual deterioration of material by chemical reaction with its environment.

- **Thermal Properties**

The study of thermal properties is essential in order to know the response of metal to thermal changes i.e. lowering or raising of temperature. Different thermal properties are thermal conductivity, thermal expansion, specific heat, melting point, thermal diffusivity. Some important properties are defined as under.

- **Melting Point**

Melting point is the temperature at which a pure metal or compound changes its shape from solid to liquid. It is called as the temperature at which the liquid and solid are in equilibrium. It can also be said as the transition point between solid and liquid phases. Melting temperature depends on the nature of inter-atomic intermolecular bonds. Therefore, higher melting point is exhibited by those materials possessing stronger Bonds. Covalent, ionic, metallic and molecular types of solids have decreasing order of bonding strength and melting point. Melting point of mild steel is 1500°C, of copper is 1080°C and of Aluminum is 650°C.

- **Electrical Properties**

The various electrical properties of materials are conductivity, temperature coefficient of resistance, dielectric strength, resistivity, and thermoelectricity. These properties are defined as under.

- **Conductivity**

Conductivity is defined as the ability of the material to pass electric current through it easily i.e. the material which is conductive will provide an easy path for the flow of electricity through it.

- **Temperature Coefficient of Resistance**

It is generally termed as to specify the variation of resistivity with temperature.

- **Dielectric Strength**

It means insulating capacity of material at high voltage. A material having high dielectric strength can withstand for longer time for high voltage across it before it conducts the current through it.

- **Resistivity**

It is the property of a material by which it resists the flow of electricity through it.

- **Thermoelectricity**

If two dissimilar metals are joined and then this junction is heated, a small voltage (in the mill-volt range) is produced, and this is known as thermoelectric effect. It is the base of the thermocouple. Thermo -couples are prepared using the properties of metals.

- **Magnetic Properties**

Magnetic properties of materials arise from the spin of the electrons and the orbital motion of electrons around the atomic nuclei. In certain atoms, the opposite spins neutralize one another, but when there is an excess of electrons spinning in one direction, magnetic field is produced. Many materials except ferromagnetic material which can form permanent Magnet, exhibit magnetic affects only when subjected to an external electro-magnetic field. Magnetic properties of materials specify many aspects of the structure and behavior of the matter. Various magnetic properties of the materials are magnetic hysteresis, coercive force and absolute permeability which are defined as under.

- **Magnetic Hysteresis**

  Hysteresis is defined as the lagging of magnetization or induction flux density behind the magnetizing force or it is that quality of a magnetic substance due to energy is dissipated in it on reversal of its magnetism. Below Curie temperature, magnetic hysteresis is the rising temperature at which the given material ceases to be ferromagnetic, or the falling temperature at which it becomes magnetic. Almost all magnetic materials exhibit the phenomenon called hysteresis.

- **Coercive Force**

It is defined as the magnetizing force which is essential to neutralize completely the magnetism in an electromagnet after the value of magnetizing force becomes zero.

- Absolute Permeability

It is defined as the ratio of the flux density in a material to the magnetizing force producing that flux density. Paramagnetic materials possess permeability greater than one whereas di-magnetic materials have permeability less than one.

- **Optical Properties**

The main optical properties of engineering materials are refractive index, absorptive, absorption co-efficient, reflectivity and transmissivity. Refractive index is an important optical property of metal which is defined as under.

- **Refractive Index**

It is defined as the ratio of velocity of light in vacuum to the velocity of a material. It can also be termed as the ratio of sine of angle of incidence to the sine of refraction.

1.2.2. Mechanical Properties

The mechanical properties of the metals are those which are associated with the ability of the material to resist mechanical forces and load. These mechanical properties of the metal include strength, stiffness, elasticity, plasticity, ductility, brittleness, malleability, toughness, resilience, creep and hardness. We shall now discuss these properties as follows:

- ***Strength*** It is the ability of a material to resist the externally applied forces without breaking or yielding. The internal resistance offered by a part to an externally applied force is called stress.

- ***Stiffness*** It is the ability of a material to resist deformation under stress. The modulus of elasticity is the measure of stiffness.

- ***Elasticity*** it is the property of a material to regain its original shape after deformation when the external forces are removed. This property is desirable for materials used in tools and machines. It may be noted that steel is more elastic than rubber.

- ***Plasticity*** It is property of a material which retains the deformation produced under load permanently. This property of the material is necessary for forgings, in stamping images on coins and in ornamental work.

- ***Ductility*** It is the property of a material enabling it to be drawn into wire with the application of a tensile force. A ductile material must be both strong and plastic. The ductility is usually measured by the terms, percentage elongation and percentage reduction in area. The ductile material commonly used in engineering practice (in order of diminishing ductility) are mild steel, copper, aluminum, nickel, zinc, tin and lead.

- ***Brittleness*** It is the property of a material opposite to ductility. It is the property of breaking of a material with little permanent distortion. Brittle materials when subjected to tensile loads, snap off without giving any sensible elongation. Cast iron is a brittle material.

- ***Malleability*** It is a special case of ductility which permits materials to be rolled or hammered into thin sheets. A malleable material should be plastic but it is not essential to be so strong. The malleable materials commonly used in engineering practice (in order of diminishing malleability) are lead, soft steel, wrought iron, copper and aluminum

Self-Check- 2	Choose the best answer

Direction-Choose the best answer

1 The temperature at which Apure meal or compound changes

A. thermal temperature C. room temperature

B. melting point D. none

2 The metals are those which are associated with the ability of the metal

A Mechanical property C Thermal property

B Physical property D None

3 Mass per unit volume is called as ____________

A Pressure A. meter

B density D. None

4 It is property of material which retains the deformation produced under load permanently.

A. plasticity C. ductility

B. elasticity D .Non

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet-3	Effects of different types of bonding in materials

1. Introduction to bonding materials

These are materials made up from, or composed of, a combination of different materials to take overall advantage of their different properties. In man-made composites, the advantages of deliberately combining materials in order to obtain improved or modified properties were understood by ancient civilizations. An example of this was the reinforcement of air-dried bricks by mixing the clay with straw. This helped to reduce cracking caused by shrinkage stresses as the clay dried out. In more recent times, horse hair was used to reinforce the plaster used on the walls and ceiling of buildings. Again this was to reduce the onset of drying cracks. Nowadays, especially with the growth of the plastics industry and the development of high-strength fibers, a vast range combination of materials is available for use in composites. For example, carbon fiber reinforced frames for tennis rackets and shafts for golf clubs have revolutionized these sports.

1.1 Atomic bonds and Structure

Although the properties of the metals used widely they all had one thing in common. No matter what their composition, no matter what changes they had gone through during extraction from the ore, refinement and processing, they were all made up of small particles.

- Atoms

Not so very long ago, in our early chemistry classes, we used to say that the atom was the smallest unit of which matter was composed and was indivisible. Also the atom is considered as the basic structural unit of matter now, it is not quite as simple as that, and the chemist no longer regards the atom as being in the nature of an in destructible little billiard-ball which is held by some mysterious force of attraction to its neighbors.

Each atom is composed of a positively charged nucleus surrounded by a sufficient number of negatively charged electrons so that the charges are balanced and neutrons which carry no charge. The number of electrons identifies the atomic number and the element of the atom.

When the atoms have gained or lost one or more electrons, it is called as" Ions". Losing of an electron makes the atom electropositive since there will be a positively charged proton without its balancing electron. Such an ion is called a positive ion. While gaining an electron makes the atom electronegative since there is no spare positively charged proton in the nucleus to balance the additional electron. Such an ion is called a negative ion.

Chemical properties are related to the numbers of electrons and protons present and in this respect there are altogether ninety-two basically different types of atom which occur naturally. Of late the scientists have succeeded in building up a series of new ones. When two or more atoms, either of one type or of different types, are joined together chemically, the unit which is produced is called a molecule. In a similar way the gases fluorine and chlorine, with seven electrons in the outer shell in each case, have like chemical properties. Both are gases (at normal temperatures and pressures) with strongly non-metallic properties. Many of the similarities and differences among the elements can be explained by their respective atomic structures as shown in Figure 7.

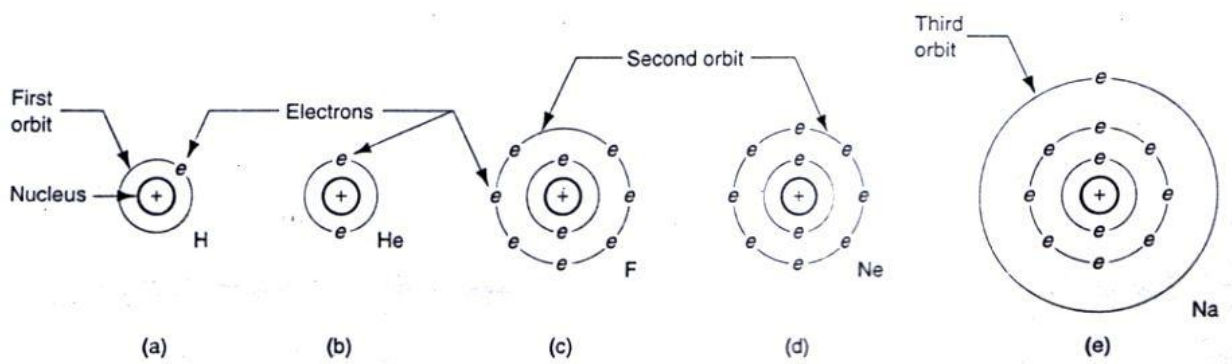


Figure 7: Simple model of atomic structure for several elements:
(a) Hydrogen, (b) helium, (c) fluorine, (d) neon, (e) sodium.

We might infer that there are a maximum number of electrons that can be contained in a given orbit. This turns out to be correct, and the maximum is defined by:

Maximum number of electrons in an orbit = $\mathbf{2\ n^2}$

Where identifies the orbit, with n = 1 closest to the nucleus.

The number of electrons in the outermost shell, relative to the maximum number allowed, determines to a large extent the atom's chemical affinity for other atoms. These outer shell electrons are called *valence electrons.* For example, since hydrogen atom has only one electron in its single orbit, it readily combines with another hydrogen atom to form a hydrogen molecule H2. For the same reason, hydrogen also reacts readily with various other elements (for example, to form H2O). In the helium atom, the two electrons in its only orbit are the maximum allowed [2n2 = 2(l) 2 = 2] and so helium is very stable. Neon is stable for the same reason. Its outermost orbit *(n = 2)* has eight electrons (the maximum allowed), so neon is an inert gas.

In contrast to neon, fluorine has one fewer electron in its outer shell (*n* =2) than the maximum allowed and is readily attracted to other elements that might share an electron to make a more stable set. The sodium atom seems divinely made for the situation, with one electron in its outermost orbit. It reacts strongly with fluorine to form the compound sodium fluoride, as pictured in Figure 8.

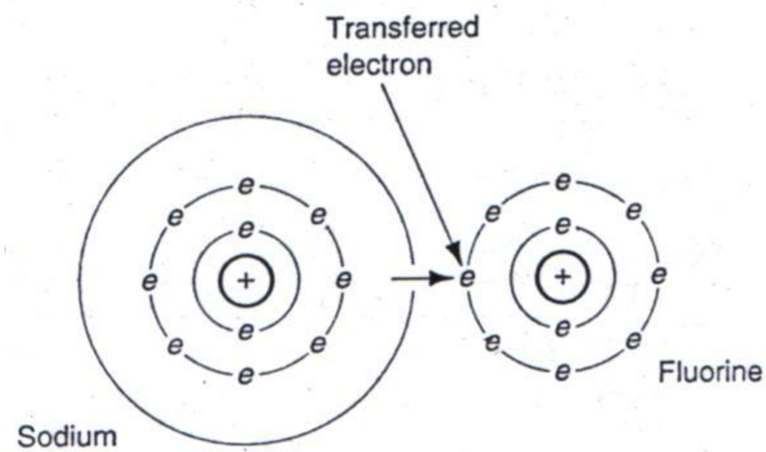


Figure 8: the sodium fluoride molecule, formed by the transfer of the extra electron of the sodium atom to complete the outer orbit of the fluorine atom**.**

1.2 Types Bonding in Materials:

It depends on the bonding between atoms and molecules where the atoms are held together in molecules by various types of bonds that depends on the valence electrons. By comparison, molecules are attracted to each other by weaker bonds, which generally result from the electron configuration in the individual molecules. Thus, we have the following types of bonding:

1. Ionic Bond

In the *ionic bond,* the atoms of one element give up their outer electron(s), which ran in turn attracted to the atoms of some other element to increase their electron count in the outermost shell to eight, as shown in figure 9. This bond is naturally provides a very Strong bond between atoms and as a properties of solid materials with the ionic bonding include low electrical conductivity and poor ductility.

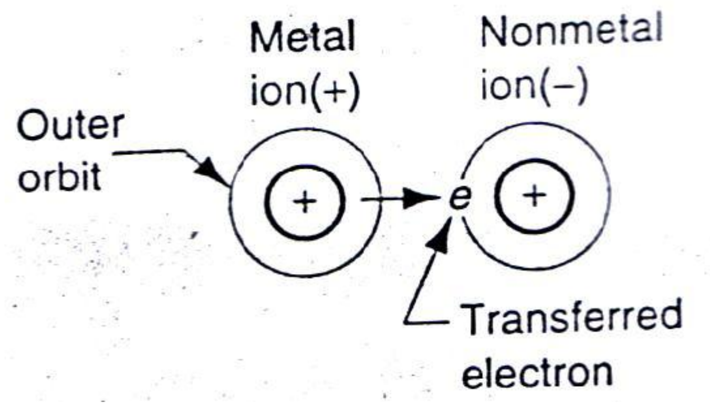


Figure 9: Ionic bond

As an example of this bond is the Sodium chloride (table salt) Isa more common example. Because of the transfer of electrons between the atoms, sodium and chlorine *ions* are formed as shown in this reaction:

$$Na^{+} + Cl^{-} \rightarrow Na^{+}Cl^{-}$$

2. Covalent Bond

In the *covalent bond,* electrons are shared (as opposed to transfer) between atoms in their outermost shells to achieve as table set of eight as shown in figure 10.

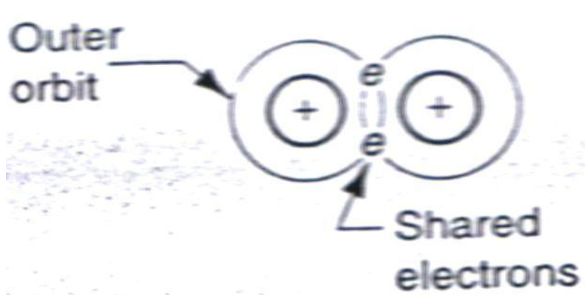
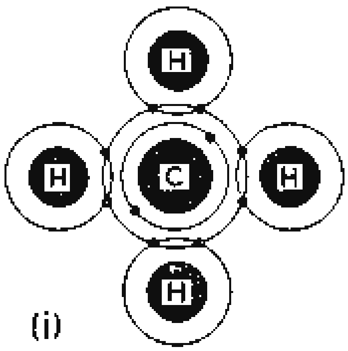
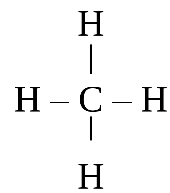


Figure 10: Covalent bond

Solids with covalent bonding generally possess high hardness and low electrical conductivity. As an example of covalent bond the molecule of the gas methane (CH4), four hydrogen atoms are combined with one carbon atom. The carbon atom has four electrons in its outer shell, but these are joined by four more electrons, contributed singly by each of the four hydrogen atoms as shown in figure 11.



(i)

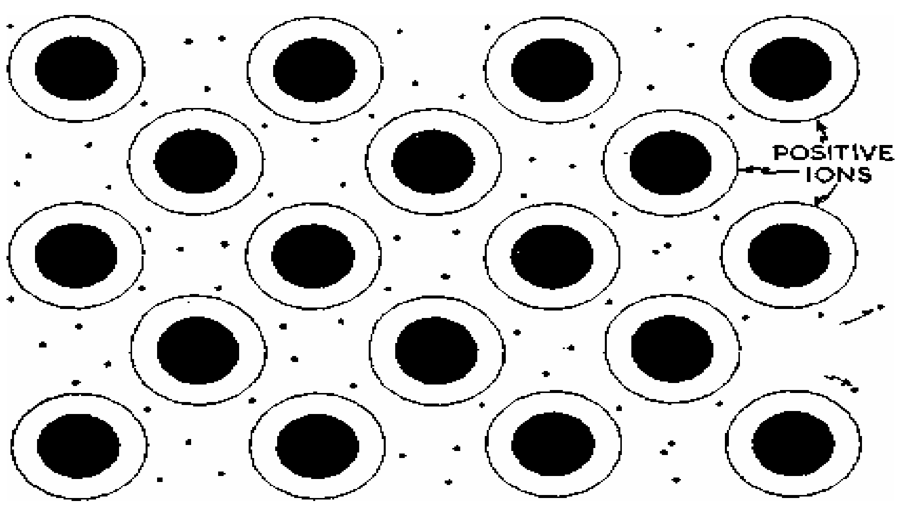


(ii)

Figure 11: (i) Covalent Bonding in a Molecule of Methane; CH4(ii) Chemists express the structural formula for the methane molecule

3. Metallic Bond

It is the atomic bonding mechanism in pure metals and metal alloys. The metallic bonding involves the sharing of outer shell electrons by all atoms to form a general electron cloud that permeates the entire block as shown in figure 12.



ELECTRON 'CLOUD'

Figure 12: Diagrammatic Representation of the "Metallic Bond".

This cloud provides the attractive forces to hold the atoms together and form a strong, rigid structure in most cases. Because of the general sharing of electrons and their freedom to move within the metal, metallic bonding provides typical properties of materials characterized such as good electrical conductivity, good conduction of heat and good ductility.

Composition, Bonding, Crystal Structure and Microstructure DEFINE Materials Properties

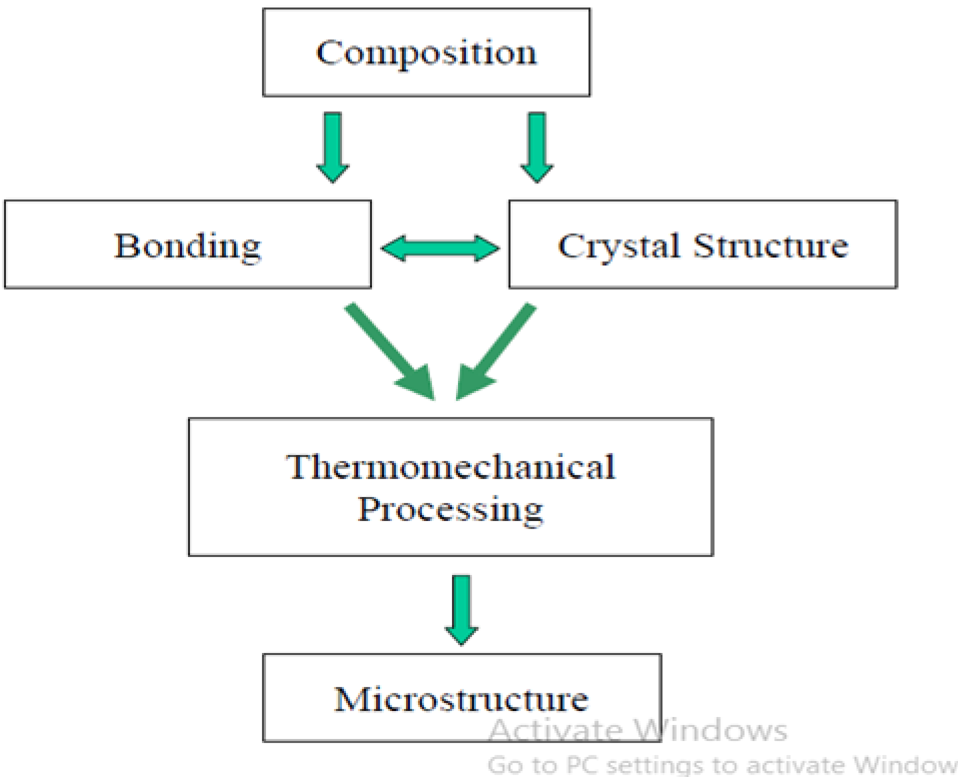


Figure.13: Materials Science and Engineering

1.3 Crystalline Structures

Many substances, including metals, have a crystalline structure in the solid state. Metals crystal structure forms when the molten metal cool and solidify. Whereas crystals of other substances, for example Copper Sulphate, and sodium chloride (salt), form when a saturated solution of compound evaporates causing the solid to crystallize. In crystalline structure, the atoms are located at regular and recurring positions in three dimensions. The pattern may be replicated millions of times within a given crystal. The structure can be viewed in the form of aunt cell, which is the basic geometric grouping of atoms that is repeated.

There are several types of pattern in which metallic atoms can arrange themselves on solidification, but the most common is as follows:-

4. **Body-Centered-Cubic [BCC]:-** As the name itself points out this type of crystal structure has central atom included in the cubic shape of shared atoms. As shown in the figure below,

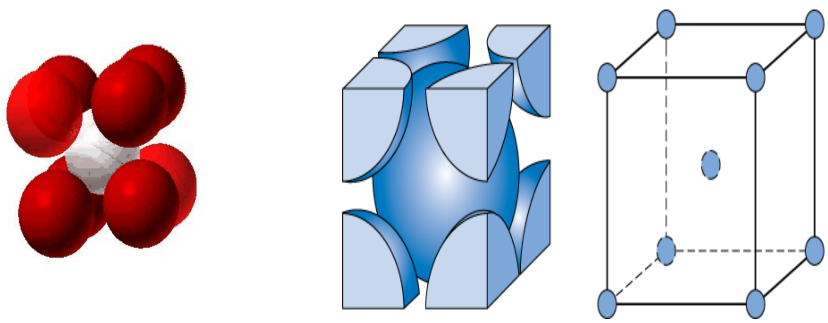


Figure 14: Body-Centered-Cubic Crystal Structure

Example of the materials for this type: Chromium, Molybdenum, Niobium, Tungsten, Iron (Fe α (at room temperature)) etc

5. **Face-Centered-Cubic [FCC**]

As shown in figure 14, this type of crystal structure has one single atom in every face of its cubic shaped atomic arrangement and unlike to BCC there is no atom which is fully included only by one cubic shape arrangement, by this meaning all atoms of FCC crystal structure are shared with neighbor cubic shaped arrangement of atoms.

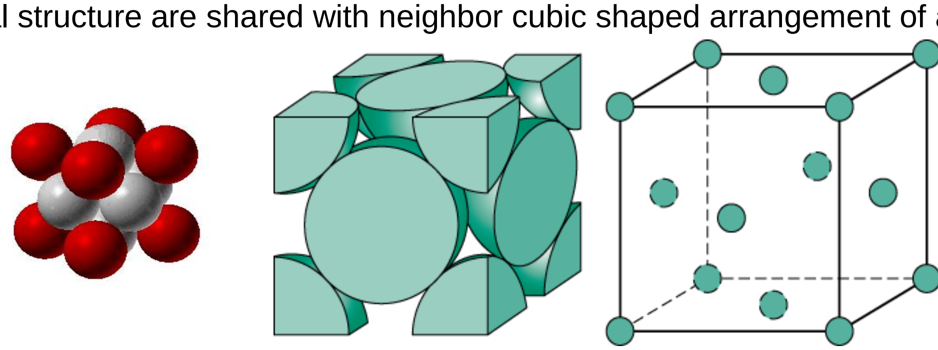


Figure.15: Face Centered Cubic (FCC) Crystal Structure

As an example of the materials for this type: Aluminum, Copper, Lead, Nickel, Iron at some high temperature, Gold, and Silvered.

6. Hexagonal-Closed-Packed [HCP]

The atomic arrangement of HCP crystal structure is more deferent and a bit complex than BCC and FCC. As shown in figure below, atoms are arranged hexagonal prism pattern and there are additional two atoms which are laid on the two faces of the hexagonal prism as well as there are additional three atoms around the center of the hexagonal shape arranged with a regular triangular pattern.

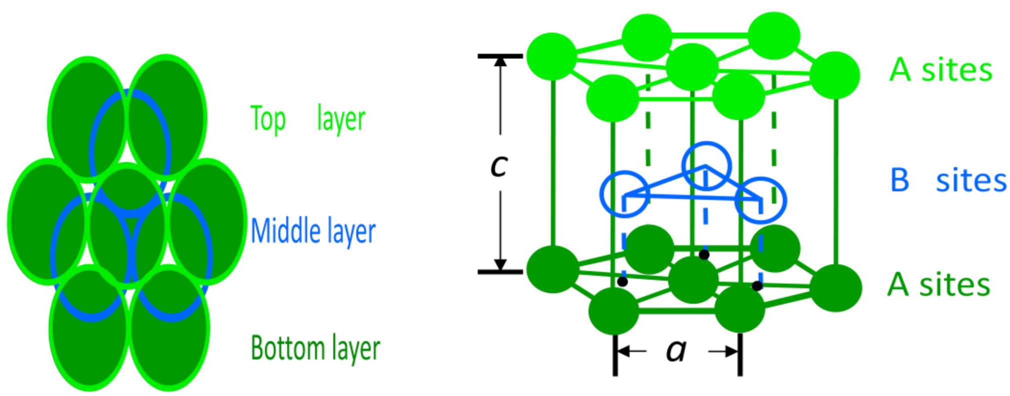


Figure 16 Hexagonal-Closed-Packed (HCP) Crystal Structure

As an example of the materials for this type: Beryllium, Cadmium, Magnesium, Zinc

Table 2: Overview of material properties with crystal structure

Type	Name	Properties	Example
FCC	Face-Centered-cubic	Ductile at all temps	Aluminum, copper, Nickel
BCC	Body-centered-cubic	ductile-brittle transition with temp or strain rate	Iron (steel) tungsten
HCP	Hexagonal-close-packed	less ductile	Magnesium, zinc

7. Non-crystalline (Amorphous) Structures:

The non-crystalline solids materials do not have their basic particles arranged in a geometric pattern. Their particles have a random formation, and such as a result, such substances are said to be amorphous (without shape).
Many important materials are non-crystalline: liquids and gases, for example. Water and air have a non-crystal structure. A metal loses its crystalline structure when it is melt. Such as glass, plastics and rubber are materials that fall into this category. Many important plastics are mixture of crystalline and non-crystalline forms. Two closely related features differentiate non-crystalline from crystalline materials: -

Materials absence of long range order in the molecular structure of a non-crystalline. It can be visualized with reference to figure below. They closely packed and repeating pattern of in the crystal structure and random arrangement of atoms in the non-crystalline

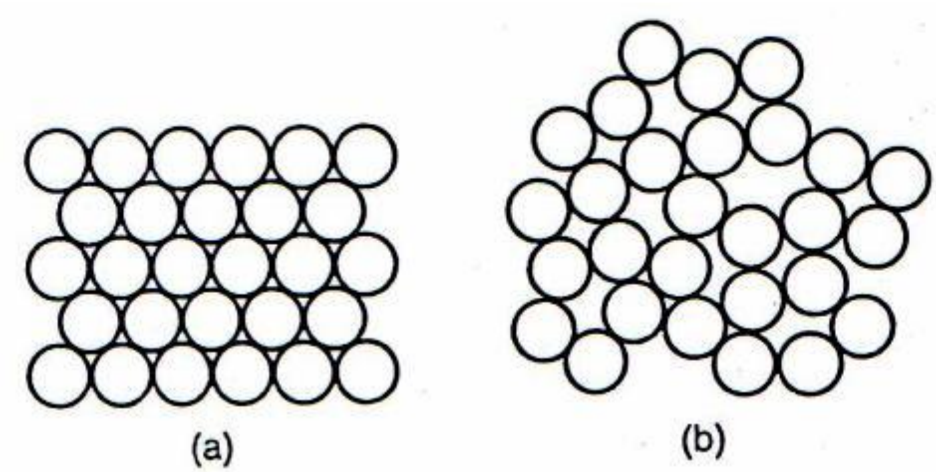


Figure.17: Difference in structure between (a) Crystalline and (b) no crystalline materials.

2. Differences in melting and thermal expansion characteristics.

It could be demonstrated by a metal when it melts. When the metal is molten an increase in volume compared to the material's solid crystalline state. This effect is characteristic most materials when melted (a noble exception is ice; liquid water is denser than ice).

3. The crystalline state:

As we mention before that all of the metals and its alloys have crystalline structure, where the atoms are rearranged in an organized shape which it is called as the crystal lattice. This lattice consisted of another smallest grouping of atoms each one is called the unit cell.

The unit cell is the smallest parallel surfaces of the crystalline structure that can be removed or repeated in different directions. It is also differ from each other in shape or size in the crystalline lattice from one material to another. The atoms that belong to the unit cell are called the basic atoms, its number is different from one shape of arrangement to another, this number can be found from the following equation: -

Self-check-3	Written-Questions

Direction-Choose the best answer

1. In the bond electrons are shared between atoms outermost shells.

   A Ionic bond
   B Covalent bond
   C Metallic bond
   D none

2 The smallest unit of which matter was composed and the indivisible.

   A proton
   B electron
   C atom
   D None

3 the same itself points out this type of crystal structure has

   A BCC
   B FCC
   C HCP
   D None

4 This types of crystal structure has one single atom in every cubic atom

   A BCC
   B HCP
   C FCC
   D .None

Answer Sheet

Score = ____________

Rating:

Name: ___________________________ Date: ________________

Information Sheet-4	.Analyzing the effects of bonding in materials

1. INTRODUCTION

1.1 The effects of bonding in materials

There are three conventional types of crystal/bond imperfections:

1 .Point defects
2. Line defects
3. Planar defects

The simplest point defects are as follows:

- Vacancy – missing atom at a certain crystal lattice position;
- Interstitial impurity atom – extra impurity atom in an interstitial position;
- Self-interstitial atom – extra atom in an interstitial position;
- Substitution impurity atom – impurity atom, substituting an atom in crystal lattice;
- Freckle defect – extra self-interstitial atom, responsible for the vacancy nearby.

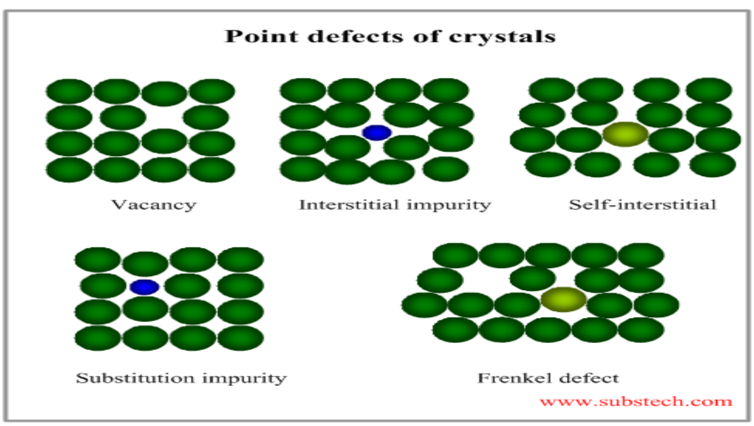


Figure.18: point defect of crystals

- **Edge dislocation** is an extra half plane of atoms "inserted" into the crystal lattice. Due to the edge dislocations metals possess high plasticity characteristics: ductility and malleability.

- **Linear crystal defects** are edge and screw dislocations.
  Edge dislocation is an extra half plane of atoms "inserted" into the crystal lattice. Due to the edge dislocations metals possess high plasticity characteristics: ductility and malleability.

- **Dislocations in the crystal structure**
  Metals are malleable and ductile; much more so than can be explained using the simple model of layers slipping past one another (see page 2). There is another feature which also helps metals change shape without breaking. The malleability and ductility are helped by the presence of dislocations in the crystal structure.

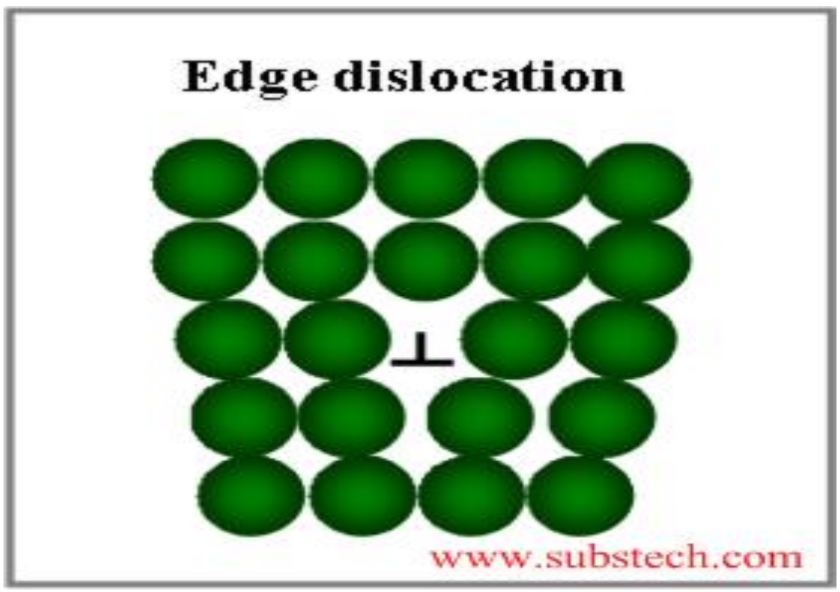


Figure 19: Dislocation in the structure crystals

The lattice will have a number of defects called dislocations. These can move through the lattice. Click to step through the movement. Note: this simple cubic lattice does not exist in nature - however, it is simple to see.

A dislocation is simply a defect in the lattice structure in which a few ions in a layer are missing. This causes the neighboring layers to be displaced slightly to minimize the strain from the defect. You can also think of it as being extra row of ions.

Moving dislocation there can be millions of dislocations in each cubic millimeter of a metal. When a force is applied to the metal, the dislocations move through the lattice structure. This only needs to be a small force (smaller than that needed to produce slip) because very few bonds are being broken at any one time.

This movement does not affect the vast majority of ions and does not require large scale movement of the layers in the structure. It is the ease of movement of dislocations that helps explain why metals are so malleable and ductile. As with slip, moving dislocations causes plastic deformation of the metal.

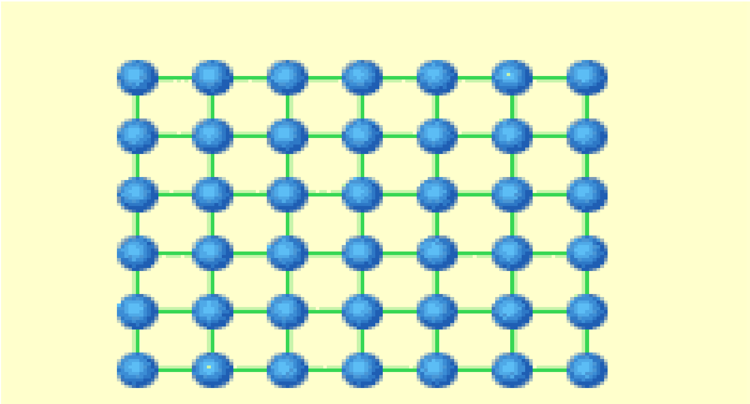


Figure.20: Photomicrograph of steel. You can see the grains in which the crystals have grown in different directio

- **Crystal grains**

Most metals are manufactured by casting molten liquid. As the liquid begins to solidify, a small number of solid nuclei appear. A single crystal grows around each nucleus. These individual crystals are called grains. The grains grow in all directions until they meet other grains. The edges of the grains are called grain boundaries.

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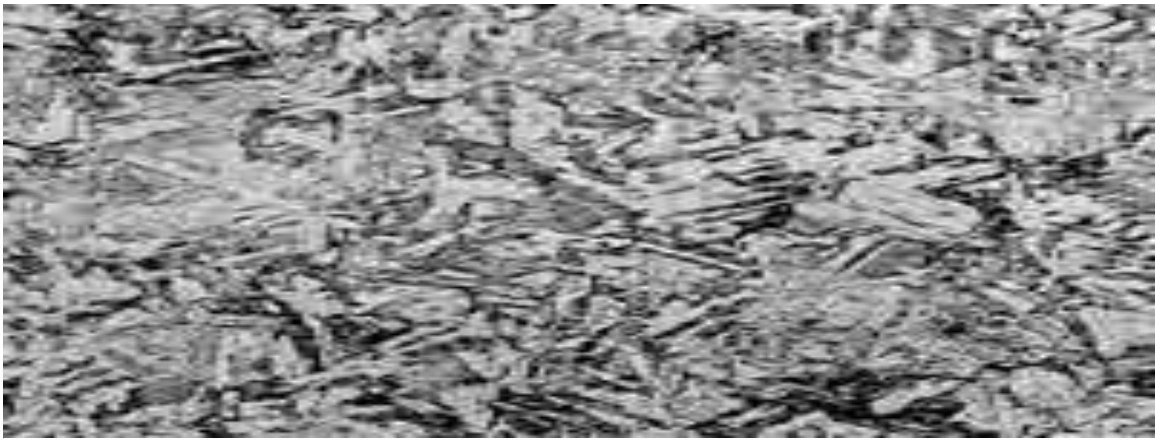


Figere.21: Diagram of grains and grain boundaries.

How grains affect dislocations the movement of dislocations is hindered by grain boundaries. The more grain boundaries there are the more difficult it is for the dislocations to move and for the metal to change shape. The result is that the metal is stiffer and harder. It is also stronger.

A fine grained metal contains a large number of grains. A coarse grained metal contains fewer grains. A fine grained metal is therefore stronger than a coarse grained metal.

Sometimes, grain refining agents are added to the molten metal before it is cast to provide nuclei around which grains can grow. This will tend to produce a finer grained material which is stronger than it would have been with fewer grains.

Self-check -4	Choose the best answer

Direction-Choose the best answer

1 Conventional types of crystal/bond imperfection

A body defects | C angel defects

B point defects | D none

2 This is an extra half plane of atoms “inserted” in to the crustal lattice.

A linear crystal defects | C planar defect

B edge dislocation | D None

3 The most metals are manufactured by casting molten liquid

A body grains | C crystal grains

B point grains | D None

4 Metals are malleable and ductile; much more so than can be explained model of layers

A edge crystal | C body crystal

B dislocation crystal structure | D None

Answer Sheet

Score = ____________

Rating:

Name: ___________________________ Date: ________________

Short Answer Questions

OPERATION SHEET 1	Determining correct materials/ components

Preparing material and equipment for metallurgy

Steps 1- Wear PPE
Steps 2- Select required material for the work
Steps 3- select required tools and equipment
Steps 4**-** cut the work pieces aluminum, steel and cast-iron
Steps 5- put distilled water, salt water only one day
Steps 6- check the property of metals
Steps 7-recored color and structural change

LAP Test	Practical Demonstration

Name: ________________________________ Date: __________________

Time started: ___2:00_am ________________ Time finished: 12:00______________

Instructions: Given necessary tools and materials you are required to perform to make simple 24hour.

Task 1 Perform to PPE.

Task 2 Perform required material for the work

Task 3 Perform required tools and equipment

Task 4 Perform cutting the work pieces aluminum, steel and cast-iron.

Task 5 Perform put distilled water, salt water only one day.

Task 6 Perform the check the property of metals

Task 7 Perform record color and structural change

Mechanics

Level-III

Learning Guide-37

Unit of Competence: **Determine Welding Materials**
Module Title **Determining Welding Materials**

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO2: Identify classes of materials based on properties

Instruction Sheet	Learning Guide #37

This learning guide is developed to provide you the necessary information follow in content coverage and topics:

- Classes, codes and calibrating requirements of materials
- Identifying and understanding common characteristics, faults or flaws in Materials and components or product.
- Identifying test methods for materials and components
- Identifying and using appropriate sources of information on properties Materials.
- Selecting appropriate sources of information on Materials Safety Data Sheets (MSDS).

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Identify classes, codes and calibrating requirements of materials, based on properties required for particular mechanical and manufacturing engineering applications with references to standard
- Identify and understand common characteristics, faults or flaws in materials and components or product in particular engineering applications with references to standard
- Identify test methods for materials and components or product in particular engineering applications
- Identify appropriate sources of information on properties materials, materials test, test calibration, test certificates, regulations and standards
- Select appropriate sources of information on Materials Safety Data Sheets (MSDS) due to applicable standards

Learning Instructions:

1. Read the specific objectives of this Learning Guide.

2. Follow the instructions described below

3. Read the information written in the information Sheet.

4. Accomplish the “Self-check 1, Self-che

5. If you earned a satisfactory evaluation from the “Self-check”

6, Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3 ” in page -15.

Information Sheet-1	Classes, codes and calibrating requirements of materials

I. INTRODUCTION

1. 1 Classes of Materials for engineering materials

- Solid materials have been conveniently grouped into three basic Classifications: metals, ceramics, and polymers. This scheme is based primarily on chemical makeup and atomic structure, and most materials fall into one distinct grouping or another, although there are some intermediates. In addition, there are three other groups of important engineering materials—composites, semiconductors, and biomaterials.
- Composites consist of combinations of two or more different materials, whereas semiconductors are utilized because of their unusual electrical characteristics; biomaterials are implanted into the human body. A brief explanation of the material types and representative characteristics is offered n

1.2 Classifications between ferrous and non-ferrous metals

Common engineering materials are normally classified as metals and non-metals. Metals and non-metals differ in their properties. The choice of materials for a given job depends very much on its properties, cost, availability and such other factors. Metals may conveniently be divided into ferrous and non-ferrous metals.

1.3 Ferrous metals

Ferrous metals may be defined as those metals whose main constituent is iron such as pig iron, wrought iron, cast iron, steel and their alloys. They are usually stronger and harder and are used in daily life products. They possess a special property that their characteristics can be altered by heat treatment processes or by addition of small quantity of alloying elements. Ferrous metals possess different physical properties according to their carbon content.

1.4 The most Ferrous metals are:

1. Cast iron

It is primarily an alloy of iron and carbon. The carbon content in cast iron varies from 1.5 to 4 per cent. Small amounts of silicon, manganese, sulphur and phosphorus are also present in it. Carbon in cast iron is present either in Free State like graphite or in combined state as cemented. Cast iron contains so much carbon or its equivalent that it is not malleable. One characteristic (except white cast iron) is that much of carbon content is present in free form as graphite. Largely the properties of cast iron are determined by this fact. Melting point of cast iron is much lower than that of steel. The characteristics of cast iron which make it a valuable material for engineering applications are:

- Very good casting characteristics.
- Low cost
- High compressive strength
- Good wear resistance
- Excellent mach inability

The main limitation of this metal is brittleness and low tensile strength and thus cannot be used in those components subjected to shocks.

The varieties of cast iron in common uses are:

- Grey cast iron
- White cast iron
- Malleable cast iron
- Nodular cast iron
- Chilled cast iron
- Alloy cast iron

2 Grey Cast Iron

It is the iron which is most commonly used in foundry work. If this iron is machined or broken, its fractured section shows the greyish colour; hence the name “grey” cast iron. The grey colour is due to the fact that carbon is present in the form of free graphite. A very good characteristic of grey cast iron is that the free graphite in its structure acts as a lubricant. This is suitable for those components/products where sliding action is desired. The other properties are good mach inability, high compressive strength, low tensile strength and no ductility. In view of its low cost, it is preferred in all fields where ductility and high strength are not required. The grey cast iron castings are widely utilized in machine tool bodies, automobile cylinder blocks and flywheels, etc.

3 White Cast Iron

It is so called due to the whitish colour shown by its fracture. White cast iron contains carbon exclusively in the form of iron carbide Fe_3C (cemented). From engineering point of view, white cast iron has limited applications. This is because of poor mach inability and possessing, in general, relatively poor mechanical properties. It is used for inferior castings and places where hard coating is required as in outer surface of car wheels. Only crushing rolls are made of white cast iron. But it is used as raw material for production of malleable cast iron.

4 Malleable Cast Iron

Malleable cast iron is produced from white cast iron. The white cast iron is brittle and hard. It is, therefore, unsuitable for articles which are thin, light and subjected to shock and vibrations or for small castings used in various machine components. The malleable cast iron is produced from white cast iron by suitable heat treatment, i.e., annealing. This process separates the combined carbon of the white cast iron into nodules of free graphite. The malleable cast iron is ductile and may be bent without rupture or breaking the section. Its tensile strength is usually higher than that of grey cast iron and has excellent machining qualities. Malleable cast iron components are mainly utilized in place of forged steel or parts where intricate shape of these parts creates forging problem. This material is principally employed in rail, road automotive and pipe fittings, etc.

5 Nodular Cast Iron

It is also known as "spherical graphite iron" or ductile iron or "High strength Cast iron". This nodular cast iron is obtained by adding magnesium to the molten cast iron. The magnesium converts the graphite of cast iron from flake to spheroid or nodular form. In this manner, the mechanical properties are considerably improved. The strength increases, yield point improves and brittleness is reduced. Such castings can even replace steel components. Outstanding characteristics of nodular cast iron are high fluidity which allows the castings of intricate shape. This cast iron is widely used in castings where density as well as pressure tightness is a highly desirable quality. The applications include hydraulic cylinders, valves, pipes and pipe fittings, cylinder head for compressors, diesel engines, etc.

6 Chilled Cast Iron

Quick cooling is generally known as chilling and the iron so produced is "chilled iron". The outer surface of all castings always gets chilled to a limited depth about (1 to 2 mm) during pouring and solidification of molten metal after coming in contact with cool sand of mould. Sometimes the casting is chilled intentionally and some becomes chilled accidentally to a small depth.

Chills are employed on any faces of castings which are required to be hard to withstand wear and friction. Chilled castings are used in producing stamping dies and crushing rolls railway, wheels cam followers, and so on.

7 Alloy cast iron

The cast irons as discussed above contain small percentages of other constituents like silicon, manganese, sulphur and phosphorus. These cast irons may be called as plain cast irons. The alloy cast iron is produced by adding alloying elements like nickel, chromium, molybdenum, copper and manganese in sufficient quantities in the molten metal collected in ladles from cupola furnace. These alloying elements give more strength and result in improvement of properties. The alloy cast iron has special properties like increased strength, high wear resistance, corrosion resistance or heat resistance. The alloy cast irons are extensively used for automobile parts like cylinders, pistons, piston rings, crank cases, brake drums, parts of. Crushing and grinding machinery etc.

8 Wrought iron

The meaning of “wrought” is that metal which possesses sufficient ductility in order to permit hot and/or cold deformation. Wrought iron is the purest iron with a small amount of slag forged out into fibres. The typical composition indicates 99 per cent of iron and traces of carbon, phosphorus, manganese, silicon, sulphur and slag.

9, steel

Steel is an alloy of iron and carbon with carbon content maximum up to 1.7%. The carbon occurs in the form of iron carbide, because of its ability to increase the hardness and strength of the steel. Other elements e.g. silicon, sulphur, phosphorus and manganese are also present to greater or lesser amount to import certain desired properties to it. Most of the steel produced now-a-days is plain carbon steel.

10. Carbon steel

Plain carbon steel is an alloy of iron and carbon. It has good machine ability and malleability. It is different from cast iron as regards the percentage of carbon. It contains carbon from 0.06 to 1.5% whereas cast iron possesses carbon from 1.8 to 4.2%. Depending upon the carbon content, a plain carbon steels can divide to the following types:

- Dead carbon steel — up to 0.15% carbon
- Low carbon or mild steel — 0.15% to 0.45% carbon
- Medium carbon steel — 0.45% to 0.8% carbon
- High carbon steel — 0.8% to 1.5% carbon

11. Dead carbon steel

It possesses very low percentage of carbon varying from 0.05 to 0.15%. It has a tensile strength of 390 N/mm2 and a hardness of about 115 BHN. Steel wire, sheets, rivets, screws, pipe, nail and chain are made from this steel.

- Low carbon or mild steel

Low carbon steel is sometimes known as mild steel also. It contains 0.20 to 0.30% C which has tensile strength of 555 N/mm2 and hardness of 140 BHN. It possesses bright fibrous structure. It is tough, malleable, ductile and more elastic than wrought iron. It can be easily forged and welded. It can absorb shocks. It rusts easily. Its melting point is about 1410°C. It is used for making angle, channels, case hardening steel, rods, tubes, valves, gears, crankshafts, connecting rods, railway axles, fish plates, small forgings, free cutting steel shaft and forged components etc.

- Medium carbon steels

Medium carbon steel contains carbon from 0.30 to 0.8%. It possesses having bright fibrous structure when fractured. It is tough and more elastic in comparison to wrought iron. It can be easily forged, welded, elongated due to ductility and beaten into sheets due to its good malleability. It can easily absorb sudden shocks. It is hard enable by treatment. It rusts readily. Its melting point is 1400°C. It can be easily hardened and it possesses good balance of strength and ductility.

It is generally used for making railway coach axles, bolts, connecting rods, key stock, wires and rods, shift and break levers, spring clips, gear shafts, small and medium forgings, railway coach axles, crank pins on heavy machines, spine shafts, crankshafts, forging dies, set screws, die blocks, self tapping screws, clutch discs, valve springs, plate punches, thrust washers etc.

■ 0.1% to 1.4% carbon.
■ up to 1.0% manganese
■ up to 0.3% silicon.
■ up to 0.05% sulphur.
■ up to 0.05% phosphorus

-

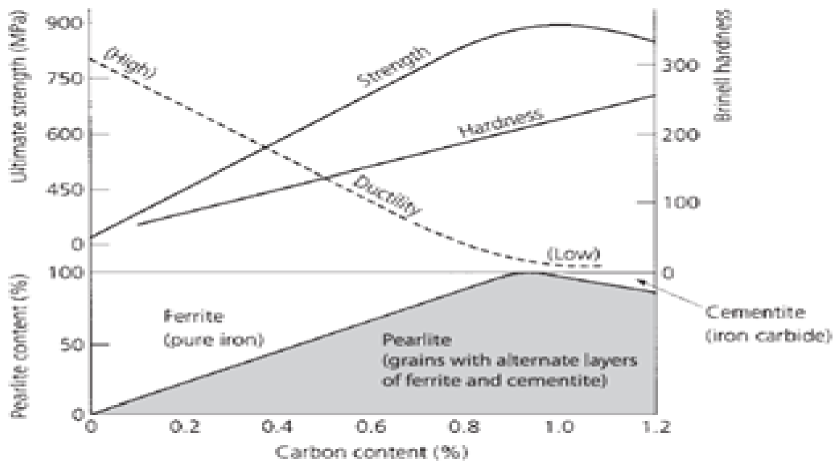


Figure 3.7 The effect of carbon content on the properties of plain carbon steels

8. High carbon steels

High carbon steels (HCS) contain carbon from 0.8 to 1.5%. Because of their high hardness, these are suitable for wear resistant parts. Spring steel is also high carbon steel. It is available in annealed and pre-tempered strips and wires. High carbon steel loses their hardness at temperature from 200°C to 250°C. They may only be used in the manufacture of cutting tools operating at low cutting speeds. These steels are easy to forge and simple to harden.

- Alloy steel

  For improving the properties of ordinary steel, certain alloying elements are added in it in sufficient amounts. The most common alloying elements added to steel are chromium, nickel, manganese, silicon, vanadium, molybdenum, tungsten, phosphorus, copper, titanium, zirconium, cobalt, columbium, and aluminium. Each of these elements induces certain qualities in steels to which it is added. They may be used separately or in combination to produce desired characteristics in the steel. The main purpose of alloying element in steel is to improve mach inability, elasticity, hardness, case hardening, cutting ability, toughness, wear resistance, tensile strength, corrosion resistance, and ability to retain shape at high temperature, ability to resist distortion at elevated temperature and to impart a fine grain size to steel.

- Free cutting steel

The important features of free cutting steels are their high mach inability and high quality surface finish after finishing. These properties are due to higher sulphur and phosphorus. Sulphur exists in the form of manganese sulphide (NMS) which forms inclusions in steel. These inclusions promote the formation of discontinuous chips and also reduce friction on the surface being machined so produces good surface finish easily.

- steel

The percentage of Nickel varies from 2 to 45 in steel. Steel having 2% Ni makes steel more suitable for rivets, boiler plates, bolts and gears etc. Steel having Ni from 0.3 to 5% raises elastic limit and improves toughness. Steel containing Nickel has very high tensile strength. Steel having 25% Ni makes it stainless and might be used for I.C. engine turbine blade etc. If Ni is present up to 27%, it makes the steel non-magnetic and non-corrodible.

Invar (Ni 36%) and super-invar (Ni 31%) are the popular materials for least coefficient of expansion and are used for measuring instruments, surveyor tapes and clock pendulums. Steel having 45% Ni steel possesses extension equal to that of glass, a property very import making links between the two materials i.e. in electronic valves and bulbs.

- Vanadium steel

Vanadium when added even in small proportion to an ordinary low carbon increases significantly its elastic limit and fatigue resistance property. Vanadium makes steel strong and tough. When vanadium is added up to 0.25%, the elastic limit of the steel is raised by 50% can resist high alternating stresses and severe shocks.

- Manganese steel

  Manganese when added in steel between 1.0 to 1.5% makes it stronger and tougher. Manganese between 1.5 to 5% in steel makes it harder and more brittle. 11 to 14% manganese in steel with carbon 0.8 to 1.5% makes it very hard, tough, non-magnetic and possesses considerably high tensile strength. Manganese steel may be forged easily but it is difficult to machine and hence it is usually ground. It is wieldable and for welding it, a nickel manganese welding rod is used.

- Tungsten Steel

  Tungsten when added to steel improves its magnetic properties and harden ability. When tungsten is added to an extent of 6% to high carbon steel, it retains the magnetic properties to high degree and produce field more intense than ordinary steel. Steel having 8% tungsten gives sufficient hardness to it to scratch even glass. It is used for making permanent magnets and high speed cutting tools.

- Silicon steel

  Silicon addition improves the electrical properties of steel. It also increases fatigue strength and ductility.

- Magnetic steels

  Steels having 15 to 40% Co, 0.4 to 1 % C, 1.5 to 9% Cr, 0-10% W and remaining Fe possesses very good magnetic properties. High Cobalt steels, when correctly heat treated, are frequently used in the making of permanent magnets for magnetos, loud speakers and other electrical machines. An important permanent magnet alloy called Alnico contains approximately 60% Iron, 20% Nickel, 8% Cobalt and 12% Aluminium. This alloy cannot be forged and is used as a casting hardened by precipitation heat treatment..

- Spring steels

  Spring steels are used for the making springs. Various types of these steel along with their composition and uses are discussed as under.

- *Carbon-manganese spring steels*:

This type of steel contains C = 0.45 to 0.6, Si = 0.1 to 0.35% and Mn = 0.5 to 1.0%. They are widely used for laminated springs for railway and general purposes.

- *Hyper-eutectoid spring steels:*

  This type of steel contains C = 0.9 to 1.2%, 0.3% (max) and Mn = 0.45 to 0.70%. This type of steel is used for volute and helical springs.

- *Silicon-manganese spring steels:*

  This type of steel contains C = 0.3 to 0.62%, Si = 1.5 to 2% and Mn = 0.6 to 1 %. This type of steel is used for the manufacturing of railway and road springs generally..

9. Stainless steel

Stainless steel contains chromium together with nickel as alloy and rest is iron. It has been defined as that steel which when correctly heat treated and finished, resists oxidation and corrosive attack from most corrosive media. Stainless steel surface is responsible for corrosion resistance. Minimum chromium content of 12% is required for the film’s formation, and 18% is sufficient to resist the most severe atmospheric corrosive conditions. Their principal alloying element is chromium while some other elements like nickel, manganese etc. can also be present in small amounts. Addition of nickel improves ductility and imparts strength.

A steel containing 18% chromium and 8% nickel is widely used and is commonly referred to as 18/8 steel. Stainless steel is highly resistance to corrosion and oxidation. High speed steels High Speed Steels (HSS) have been given this name due to the fact that these steels may be operated as cutting tools at much higher speeds that are possible with plain carbon tool steel. High speed steels cutting tools operate at cutting speed 2 to 3 times higher than for High carbon steels. At higher cutting speeds, sufficient heat may be developed during the cutting process. This heat causes the cutting edge of the tool to reach a high heat (red heat). This heat softens the carbon tool steel and thus the tool will not work efficiently for a longer period. These steels have the property of retaining their hardness even when heated to red heat. High hardness at elevated temperatures is developed by addition of elements such as tungsten, chromium vanadium to high carbon steels. These steel are generally used for making lathe cutting tools, planner cutting tools, shaper cutting tools, slotting cutting tools, drills, reamers, broaches, milling cutter and punches.

10. Non-ferrous metals

Non-ferrous metals are those which do not contain significant quantity of iron or iron as base metal. These metals possess low strength at high temperatures, generally suffer from hot shortness and have more shrinkage than ferrous metals. They are utilized in industry due to following advantages:

- High corrosion resistance
- Easy to fabricate, i.e., machining, casting, welding, forging and rolling
- Possess very good thermal and electrical conductivity
- Attractive colour and low density

  The various non-metals used in industry are: copper, aluminium, tin, lead, zinc, and nickel, etc., and their alloys.

11. Copper

Copper is one of the most widely used non-ferrous metals in industry. It is extracted from ores of copper such as copper glance, copper pyrites, malachite and azurite. Copper is a corrosion resistant metal of an attractive reddish brown colour. Common Properties of copper are:

- *High Thermal Conductivity*: Used in heat exchangers, heating vessels and appliances, etc.
- *High Electrical Conductivity*: Used as electrical conductor in various shapes and forms for various applications.*)Good Corrosion Resistance*: Used for providing coating on steel prior to nickel and chromium plating
- *High Ductility*: Can be easily cold worked, folded and spun. Requires annealing after cold working as it loses its ductility.

The following two important copper alloys are widely used in practice:

- Brass (Cu-Zn alloy)-

It is fundamentally a binary alloy with Zn up to 50% . As Zn percentage increases, ductility increases up to ~37% of Zn beyond which the ductility falls. Small amount of other elements viz. lead or tin imparts other properties to brass. Lead gives good machining quality and tin imparts strength. Brass is highly corrosion resistant, easily Machine able and therefore a good bearing material.

12. Bronze (Cu-Sn alloy)-

This is mainly a copper-tin alloy where tin percentage may vary between 5 to 25. It provides hardness but tin content also oxidizes resulting in brittleness. Deoxidizers such as Zn may be added. *Gun metal* is one such alloy where 2% Zn is added as deoxidizing agent and typical compositions are 88% Cu, 10% Sn, 2% Zn. This is suitable for working in cold state. It was originally made for casting guns but used now for boiler fittings, bushes, glands and other such uses.

13. Aluminium

Aluminium is a white metal which is produced by electrical processes from clayey mineral known as bauxite. In its pure state, it is weak and soft but addition of small amounts of Cu, Mn, Si and Mg makes it hard and strong. It is also corrosion resistant, low weight and non-toxic.

Common Properties of Aluminium are**:**

Like copper it is also corrosion resistant.

- It is very good conductor of heat and electricity although not as good as copper.
- Possesses high ductility and light weight so widely utilized in aircraft industry.
- Needs frequent annealing if cold worked since it becomes hard after cold working.
- In view of its ductility and malleability it has replaced copper in electrical transmission and appliances to some extent.
- It is used in manufacturing of household utensils including pressure cookers.
- The following important Aluminium alloys are widely used in practice:
- *Duralumin*- This is an alloy of 4% Cu, 0.5% Mn, 0.5% Mg and aluminium. It is widely used in automobile and aircraft components.

- *Y-alloy*- This is an alloy of 4% Cu, 1.5% Mn, 2% Ni, 6% Si, Mg, Fe and the rest is Al. It gives large strength at high temperature. It is used for aircraft engine parts such as cylinder heads, piston etc.
- *Magnesium*- This is an aluminium alloy with 2 to 10 % magnesium. It also contains 1.75% Cu. Due to its light weight and good strength it is used for aircraft and automobile components.
- Nickel

  Nickel is a silvery shining white metal having extremely good response to polish. The most important nickel's ore is iron sulphides which contain about 3% of nickel. About 90% of the total production of nickel is obtained by this source. Nickel is as hard as steel. It possesses good heat resistance. It is tough and having good corrosion resistance. Its melting point is 1452°C and specific gravity is 0.85. At normal temperature, nickel is paramagnetic. When it contains small amount of carbon, it is quite malleable. It is somewhat less ductile than soft steel, but small amount of magnesium improves ductility considerably.

  The important nickel alloys are haste alloy, Morel metal, Ancones, no monic and ni-chrome.

  - *Haste Alloy or high Temperature Alloy*

  Haste alloy or high temperature alloy is mainly a nickel base alloy. It contains Ni = 45%, Cr = 22%, Mo = 9%, Co = 1.5%, W = 0.5%, C = 0.15% and Fe Remaining

  The high temperature alloys are those alloys which can withstand high temperatures about 1100°C. These alloys are used in components of nuclear plants, jet and rocket engines etc.
- *Monel Metal*

  Money metal is an important alloy of nickel and copper. It contains 68% Ni, 30% Cu, 1% Fe and small amount of other constituents like manganese, silicon and carbon. Money metal is also used for pump fittings, condenser tubes, sea water exposed parts etc. It is widely used for making turbine blades, containers, parts for chemical plants, food handling machinery parts, marine parts, pump impellers, propellers, evaporators and heat exchangers in chemical works.

- *Intone*

  Inconel contains Ni = 80% Cr = 14% Fe = 6% Inconel is used for making springs, exhaust manifold of aircraft engines, machinery for food processing industries, especially milk and milk products. It is widely used for processing uranium and for sheathing for high temperature heating elements.

- *Nomadic alloy*

  The composition of no manic alloy is given as under. Cr = 15 to 18%, Co = 15 to 18%, Ti = l.2 to 4.0%, Al = l.5%, Ni = Remaining. Nomonic is widely used for making gas turbine engines

- *Ni-Chrome*

  Ni-chrome contains Ni = 60%, Cr = 15%, Fe = 20%. Ni-chrome is non-corrosive. It can easily withstand high temperatures without oxidation. Ni-chrome is commonly used for making electrical resistance wire for electric furnaces and heating elements.

- Lead

  Lead is a bluish grey metal with a high metallic lustre when freshly cut. It is the softest and heaviest of all the common metals. It is very malleable and may be readily formed into foil. It can readily be scratched with fingernail when pure. Lead has properties of high density and easy workability. It has very good resistance to corrosion and many acids have no chemical action on it. Its melting point is 327°C and specific gravity is 11.35. Lead and its alloys as engineering material have limited but important uses. Lead alloys are used for soldering (Pb–Sn, Pb–Sn–Sb) and bearings (Pb–Sn–Sb, Cu–Pb, and Cu–Sn–Pb).Lead is used in safety plug in boilers, fire door releases and fuses. It is also used in various alloys such as brass and bronze. It finds extensive applications as sheaths for electric cables, both overhead and underground. Its sheets are used for making roofs, gutters etc. It is employed for chemical laboratory and plant drains. In the soldering process, an alloy of lead and tin is most widely utilized as a solder material for joining metals in joining

- ZINC

  Zinc is bluish grey in colour and is obtained from common ores of zinc are zinc blende (ZnS), zincite (ZnO), calamine ($ZnCO3$). The oxide is heated in an electric furnace where the zinc is liberated as vapour. The vapours are then cooled in condensers to get metallic zinc. Zinc possesses specific gravity is 6.2 and low melting point of 480°C. Its tensile strength is 19 to 25 MPa. It becomes brittle at 200°C and can be powdered at this temperature. It possesses high resistance to corrosion. It can be readily worked and rolled into thin sheets or drawn into wires by heating it to 100-150°C.With regards to industrial applications; zinc is the fourth most utilized metal after iron, aluminium, and copper. Zinc is commonly used as a protective coating on iron and steel in the form of a galvanized or sprayed surface. It is used for generating electric cells and making brass and other alloys. The oxide of zinc is used as pigment in paints. Parts manufactured by zinc alloys include carburettors, fuel pumps, automobile parts, and so on.

- TIN

  Tin is recognized as brightly shining white metal. Tin is considered as a soft and ductile material. It possesses very good malleability. Its melting point is 232°C and specific gravity is 7.3. It is malleable and hence can be hammered into thin foils. It does not corrode in wet and dry conditions. Therefore, it is commonly used as a protective coating material for iron and steel. The main source of tin is tinstone. To obtain crude tin, the ores of tins are crushed, claimed, washed and then smelted in a furnace using anthracite coal and sand. Tin-base white metals are commonly used to make bearings that are subjected to high pressure and load. Tin is used as coating on other metals and alloys owing to its resistance to corrosion. It is employed in low melting point alloys as a substitute for Bismuth. It is generally preferred as moisture proof packing material. Because of its high malleability, it finds application in tin cans for storing food and food items.

- Titanium and Titanium Alloys

  In process industry unalloyed titanium is commonly used. Titanium is selected for its excellent corrosion resistance properties in large varieties of environments, especially in applications where high strength is not required. However, because of high cost its use is limited to exchanger tubes using sea water as coolant and for some specific corrosive chemicals. Titanium is light compared to iron (about 50%)

and therefore it has the advantages of having lower weight to strength ratio. Ti6 Al–4V alloy is widely used titanium alloy where strength and toughness are require.

FOR CAST IRON			
GRADE	SMAW	GMAW	GTAW
Ni	SN EN	M-SN	T-SN
NiFe	FN FN-S	M-FN M-FN(Ti)	T-FN
Fe	IGF-1 IGF-2		

FOR MILD STEEL, HIGH TENSILE STEEL & LOW ALLOY STEEL			
STEEL TYPE	SMAW	FCAW	SAW
Mild steel	FM FM-2 SOH LC		Bond-50KH
TS ≧490MPa	LF	MT-53H	U-36
TS ≧590MPa	LF-60	MT-60H	UT-60
TS ≧690MPa	LF-70		Bond-CXL-1
TS ≧780MPa	LF-80		
Low Alloy steel	TM-85 TM-50CR MOC-1 MOCN-23	MT-CW-1 MT-CW-23 MT-511 MT-521 MT-502F MT-MOCN-23	

Self-check 1	Choose-Questions

Direction-Choose the best answer

1. It is primarily an alloy of iron and carbon Composites.
   A Pig iron C cast iron
   B Grey cast iron D none

2 .Approximate %age of carbon in white cast iron____________

A 2.5–2.3% C 1.7–2.3%
B 1.5–3.8% D None

3 The characteristics of cast iron which make it evaluable material for engineering application are

A Good wear resistance C Difficult mach inability
B High cost value D None

4. Approximate percentage of carbon in grey cast iron ___________

A 1.7–2.3% C. 0 %
B 2.5-3.8% D. none

Answer Sheet

Score = ____________

Rating:

Name: _________________________ Date: _______________

Short Answer Questions

Information Sheet-2	Identifying and understanding common characteristics, fault or flaws in Materials and components or product

1. Introduction to Common characteristics faults in Materials

All metals contain defects. These can range from faults on an atomic scale that are Inherent to crystallographic structures, to larger defects that are introduced during Processing. These latter defects may be avoidable or at least reduced to a level whereby they pose no threat. The complex chemical and physical reactions that take place in the both the molten and solid state can produce effects resulting in both in homogeneities and defects in the material. Non-uniform properties can present problems during the processing, fabrication and subsequent service of metal components. Defects may be characterized not only by their origin, but also by their shape. Stresses Are concentrated at notches, which occur at sudden changes in geometry. Very high Concentrations of stress can develop at sharp notches. This is why planar defects such as cracks, laminations, lack of fusion and lack of penetration type defects are potentially serious. Three-dimensional (volumetric) defects create a lesser notch effect, but can Amplify stresses by reducing the load bearing area.

The following characteristics are some that is taken into account when assessing the significance of a defect:

- size
- sharpness
- orientation with respect to both the principle working stress and residual stress
- Location with respect to the joints, the exterior surfaces and critical sections of the structure.

1.2 Primary Production Defects

Defects may be introduced when raw materials are made into a shape suitable for Further processing. For convenience, the main defect types may be classified into the Following broad descriptions. Those where the material has started out in the molten state:

- segregation,
- holes and porosity,
- shrinkage and piping,
- inclusions,
- shrinkage and hot tears

And others where the metal is solid and is being processed further:

- cracks,
- surface defects,
- residual stresses,
- embrittlement effects
- Pipe and Shrinkage

When molten metal is poured into an ingot mold it cools, starts to solidify and contracts. The outer surfaces solidify first and become fixed, while the center remains molten and, as it in turn cools and contracts, a depression is formed in the top. If a source of molten metal is not maintained a t the top of the ingot this depression can be quite deep. It is known as primary pipe. As the last of the ingot solidifies while isolated from any extra source of feeding, contraction cavities form at the core. This is known as secondary pipe. Primary pipe is relatively easy to detect by eye and as it is exposed to the atmosphere it will oxidize and must be removed before further processing takes place. Secondary pipe, on the other hand remains hidden from view and although heavy forging may re-weld the cavities they may not be fully eradicated.

- **Porosity**

Molten metal has a much higher solubility of gas than the solid. As a result, a proportion of the gas that becomes dissolved in the molten state becomes ejected and trapped on solidification. This gives a wide dispersion of gas throughout the ingot or casting. A proportion of the gas may also remain dissolved and cause problems later in the processing cycle or in service. Gas can also be produced by chemical reactions between some of the constituents within the melt. For example, hydrogen dissolved in copper reacts with dissolved oxygen to form steam bubbles. Such gaseous evolution or effervescence is not necessarily detrimental though. It can be utilized to counteract the Effects of pipe and shrinkage and may readily weld up on heavy forging provided it is

- Surface Defects

For certain products, such as those that will have no machining after casting, the surface finish is important and the mold surface texture is reflected in that of the casting surface. Any blemishes or high and low spots will be carried over onto the product. For Permanent molds, this means great attention to detail must be paid to cleanliness and

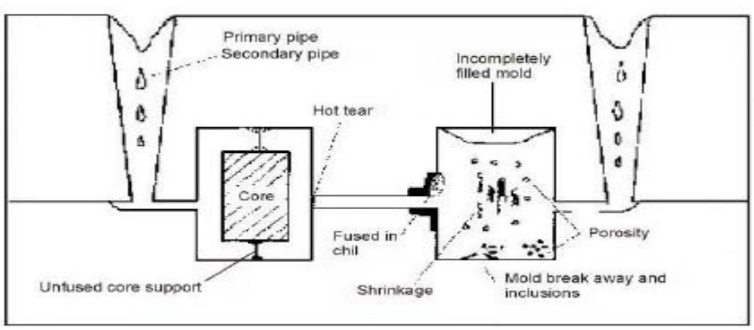


Figure 22: Composite Drawing of Typical Casting Defects

- Cracks, Laps and Seams

Closed-die forging produces a sliver of material which is forced out between the dies. This is known as “flash”. The flash is removed after forging, but if the strain

Experienced during extrusion of the flash is excessive, the flash may crack. Occasionally the cracks can run into the forging and remain when the flash has been removed. The resultant defect is known as a flash crack.

- Welding Defect

With current that is too low, there is not enough heat to melt the base metal and the molten pool will be too small. The result is poor fusion and irregular shaped deposit that piles up, as shown in figure 7-12, view B. This piling up of molten metal is called overlap. The molten metal from the electrode lays on the work without penetrating the base metal. Both undercutting and overlapping result in poor welds, as shown in figure 7-13.

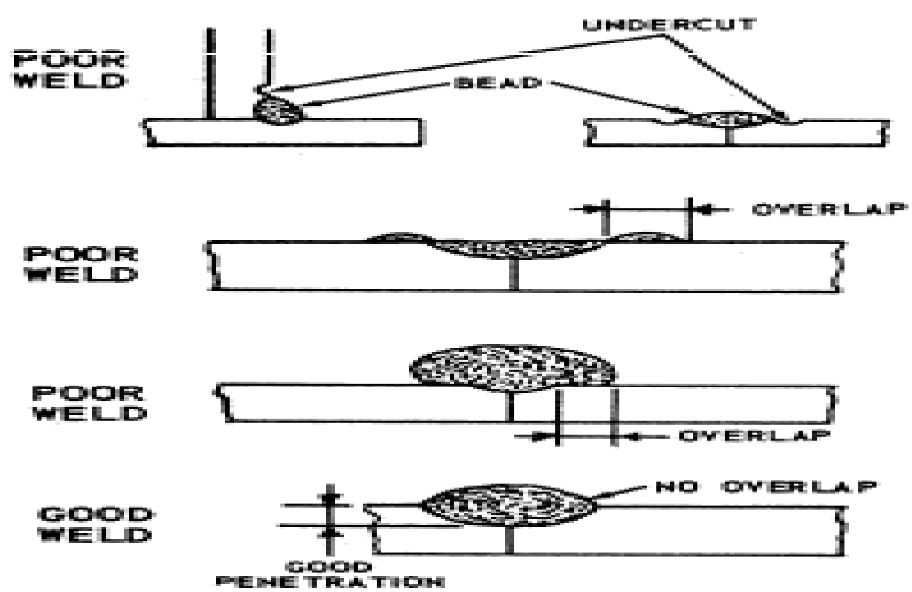


Figure 7-13.—Undercuts and overlaps in welding.

- **Electrode Selection**

several factors are critical when you choose an electrode for welding. The welding position is particularly significant. Table 7-2 shows the recommended current types and welding positions for the most common electrodes.

As a rule of thumb, you should never use an electrode that has a diameter larger than the thickness of the metal that you are welding. Some operators prefer larger electrodes because they permit faster travel, but this takes a lot of expedience to produce certified welds.

Position and the type of joint are also factors in determining the size of the electrode. For example, in a thick-metal section with a narrow view, a small-diameter electrode is always used to run the frost weld or root pass. This is done to ensure full penetration at the root of the weld. Successive passes are then made with larger electrodes

All mild steel and low-alloy electrodes are classified with a 4 or 5 digit number prefixed by "E."

Prefix "E" = Electrode

First two (or three) digits = Tensile strength (psi) (stress relieved or as welded)

Third (or fourth) digit = Position of welding

1 = all positions (flat, horizontal, vertical, overhead)

2 = horizontal and flat positions only

FOURTH DIGIT	TYPE OF COATING	WELDING CURRENT
1	cellulose potassium	ac or dc Reverse or Straight
2	titania sodium	ac or dc Straight
3	titania potassium	ac or dc Straight or Reverse
4	iron powder titania	ac or dc Straight or Reverse
5	low hydrogen sodium	dc Reverse
6	low hydrogen potassium	dc or dc Reverse
7	iron powder iron oxide	ac or dc
8	iron powder low hydrogen	dc Reverse or Straight or ac
0*	see reference below	

EXAMPLE

*When the fourth digit is 0, the type of coating and current to use are determined by the third digit. For example, E-6010 indicates a cellulose sodium coating and operates on dc reverse, while E-6020 has an iron oxide coating and operates on ac or dc.

Figure 23 —Explanation of AWS classification numbers.

Self-check.2	Written-Questions

Direction-Choose the best answer

1Molten metal has higher solubility of gas than the solid

A. cracks
B. porosity
C shrinkage
D Pyrite

2. Those that will have no machining after casting and mold surface texture.

A. Surface crack
B. embitterment effect
C holes and porosity
D.None

3. Closed-die forging produces a silver of material which is forced out between the dies

A. surface crack
B. cracks, laps and seams
C. embattlement
D.None

4. that is taken in to account when assessing the significance of defect

A. crack
B. shapeless
C. sharpness
D .None

Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet-3	Identifying test methods for materials and components

1. General methods of Simple tests

Simple tests can be conducted in the shop to identify the different metals. Since the ability to judge can be developed only through personal experience, practice these tests with known metals until you are familiar with the reactions of each metal to each type of test. The tests are described in the following subparagraphs.

- **Appearance.** Analysis, as the name implies, is based on the general appearance of the metal, which includes such general features as the color and texture of machined and un machined surfaces. It is obvious that the appearance portion of this type test is not an extremely accurate method; however, the experienced metalworker can make a reasonably good determination based on experience and the above mentioned characteristics. The chemical analysis procedure referred to in the following paragraphs is confined to the analysis used to distinguish between aluminum and magnesium, and between steel and aluminum or lead.

- **Fracture**. The fracture of many metals may be used for identification through the appearance of the fracture and study of metal chips. This test is made by simply notching a specimen and then breaking it. Although no measurable indications of the properties of a metal are obtained from this test, many metals can, through experience, be quickly identified by examining the surface of the break, or by studying the Chips produced with a hammer and chisel. The fracture test is probably the oldest of the methods used

- **Sparks**. When the exact type of material is unknown, a spark test May be used to determine its identity. The test is conducted by a study of the sparks formed when the material is held against a high-speed Grinding wheel. A grinding wheel may be used on the various types of iron and steel because they produce sparks which vary in eight, shape, and color when held lightly against a grinding wheel.

1.2 Scope

- This Section gives the requirements for testing procedures, testing machines and test specimens for mechanical and technological tests of materials.
- Alternative testing procedures and test specimens such as those complying with recognized standards may be accepted by agreement with the Society.
- The tests to be performed and the results to be obtained are given in the articles of the Rules dealing with each product. The general conditions given in Sec 1 also apply.

1.3 Testing machines

- Testing machines are to be maintained in satisfactory condition and recalibrated at approximately annual intervals for adequate reliability, accuracy and sensitivity. The calibration is to be traced to a nationally recognized authority and is to be to the satisfaction of the Society. The records of the calibration are to be made available to the Surveyor, kept in the test laboratory and copies provided on request.

- Tension/compression testing machines are to be calibrated in accordance with ISO 7500-1 or other recognized standard. The accuracy of tensile test machines is to be within plus or minus one percent.

- Chirpy impact testing machines are to have a striking energy of not less than 150J and are to be calibrated in accordance with ISO 148-2 or other recognized standard

1.4 Preparation of test specimens

- The samples for test specimens are to be in the same condition as the product from which they have been taken and therefore in the same heat treatment condition, if any.

- If the test samples are cut from products by flame cutting or shearing, a reasonable margin is required to enable sufficient material to be removed from cut or sheared edges during final machining. Test specimens are to be prepared in such a way that they are not subjected to any significant straining or heating which might alter the properties of the material

1.5 Tensile test specimen

Test specimens of proportional type should preferably be used as the values of minimum percentage elongation after fracture specified in the Rules refer to the gauge length L0 of these test specimens calculated by the following formula this gauge length L0 should preferably be greater than 20 mm. The gauge length may be rounded off to the nearest 5 mm provided that the difference between this length and L0 is less than 10% of L0.

- **Proportional flat test specimen**

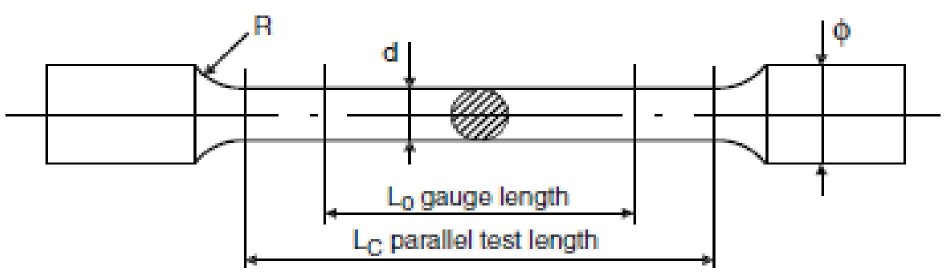
For plates, strips and sections, proportional flat test specimens are usually used, with dimensions as shown in Figure 3 below. For such products the tensile test specimens are to retain the original raw surfaces of the product. When the capacity of the testing machine is insufficient to allow the use of test specimens of full thickness, this may be reduced by machining one of the raw surfaces.

- **Round proportional test specimen**

Alternatively to the flat test specimen for plates, strips or sections equal to or greater than 40 mm thick, proportional round test specimen, machined to the dimensions shown in Fig 3, may be used.

Round proportional test specimen is used for rolled products in aluminum alloy with thickness higher than 12,5mm. For rolled bars, forgings and castings, grey cast iron excluded, round proportional test specimen are usually to

Figure 3 : Round proportional specimen



d	:	From 10 to 20 mm, preferably taken equal to 14 mm
L_0	:	Original gauge length, in mm, equal to $5 \cdot d$
L_C	:	Parallel test length, in mm, such as $L_C \geq L_0 + d / 2$
R	:	10 mm (for nodular cast iron and materials with a specified elongation less than 10%, $R \geq 1.5d$)

- **Round test specimen position**

For plates, strips and sections with thickness equal to or greater than 40 mm, the longitudinal axis of the round test specimen is to be located at a distance from one of the surfaces equal to one quarter of the thickness. For rolled products in aluminum alloy with thickness up to and including 40mm, the longitudinal axis of the round test specimen is to be located at mid-thickness. For thicknesses over 40mm, the longitudinal axis of the test specimen is to be located at a distance from one of the surfaces equal to one quarter of the thickness. For bars and similar products, the longitudinal axis of the round test specimen is to be located at one third of the

Table 4 : Test assemblies and mechanical tests required

Test assembly						Tests required **(1)**
Type	Welding position **(2)**	Electrode diameter (mm) **(3)**	Number of samples	Thickness (mm)	Dimensions	
Deposited metal	Flat	4	1 **(4)**	20	Fig 1	1TL-3KV
		max.	1			
Butt weld	Flat	First run: 4 - Intermediate: 5 Last two layers: max	1 **(5)**	15 - 20	Fig 2	1TT-1RB-1FB-3KV
	Vertical upward	First run: 3,25 Remaining runs: 4	1			1TT-1RB-1FB-3KV
	Horizontal **(6)**	First run: 4 Remaining runs: 5	1			1TT-1RB-1FB-3KV
	Overhead	First run: 3,25 Remaining runs: 4	1			1TT-1RB-1FB
Fillet **(7)**		First side: min. diam.	1	15 - 20	Fig 3, Fig 4	Macro- Fracture-Hardness
		Second side: max.diam.				

(1) Abbreviations: TL: longitudinal tensile test; TT: transverse tensile test; RB: root bend test; FB: face bend test; KV: Charpy V-notch impact test.
(2) When the approval is requested only for one or more specified welding positions, the butt test samples are to be welded in such positions.
(3) In the case of high efficiency (≥130) electrodes, electrodes having diameter 3,25 mm and 4 mm are to be used instead of 4 mm and 5 mm, respectively.
(4) If only one diameter is to be approved, only one test assembly is required.
(5) For electrodes to be approved in flat position only, an additional test sample is to be welded using electrodes having diameter 4 mm for the first pass, 5 mm for the second pass and the maximum diameter to be approved for the following passes.
(6) The test sample in the horizontal position is not required when the same test sample is welded in flat and vertical positions.
(7) See [2.5].

The specimens shown in Fig 1 are to be taken for the following tests:

a) one longitudinal tensile test

b) three Charpy V-notch impact tests.

The results of the tests are to comply with the requirements of Tab 6, as appropriate.

The chemical analysis of the deposited weld metal in each test assembly is to be supplied by the Manufacturer and is to include the content of all significant alloying elements, if

- **Approval tests**

The welding consumables are approved subject to a satisfactory inspection of the Manufacturer's works by the Surveyor and to satisfactory results of approval tests. The approval tests required are to be performed on samples

of consumables representative of the production. Sampling procedures are to be agreed with the Surveyor

In general, the approval tests consist of the following Checks:

- check of the mechanical properties of the deposited metal and welded joints and of the chemical composition of the deposited metal
- check of the hydrogen contents, where required
- check, at the request of the interested parties, of freedom from hot cracks, under specific test conditions.
- Welding and inspection of the test samples and mechanical tests are to be carried out in the presence of the Surveyor. The tests are to be carried out in laboratories and test rooms recognized by the Society. Unless otherwise specified, test specimens and procedures are to be in accordance with the applicable Society requirements or standards recognized by the Society.

- **Test Certificates**

Upon satisfactory completion of the approval tests, a certificate Of approval, stating the grade under which the consumable Has been approved and the terms of validity of the Approval is issued by the Society to the Manufacturer. The approved welding consumables and relevant grades are entered in the special lists of consumables approved by the

Table 4: The effects of individual alloying elements are shown in tabular form below:

Alloying Element	Effect on Strengthening Ferrite	Effect in Forming Carbides	Effect on Transformation Temperatures	Effect on Harden ability
Manganese	Strong	Weak	Lowers	Strong
Silicon	Strong	None	Raises	Moderate
Phosphorus	Strong	None	Lowers	Moderate
Nickel	Moderate	None	Lowers	Moderate
Chromium	Weak	Moderate	*	Strong
Copper	Moderate	None	Lowers	Weak
Molybdenum	Strong	Strong	Raises	Strong
Vanadium	Weak	Strong	Raises	Mild
Tungsten	Moderate	Strong	Raises	Moderate

Self-check.3	Written-Questions

Direction-Choose the best answer

1. Which includes such general features as the color and texture of machined
   A. fracture C spark
   B appearance D none
2. It may be used to determine its identity of metals
   A. fracture C. spark
   B. appearance D.None
3. This test is made by simply notching a specimen and then breaking it.
   A. fracture C. spark
   B. appearance D.None
4. Which can be conducted in the shop to identify the different metals?
   A. shear test C. compact test
   B. simple test D.none

Note: Satisfactory rating – 2 and 3 points Unsatisfactory - below 2 and 43points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: ______________

Name: ___________________________ Date: ________________

Information Sheet-4	Identifying and using appropriate sources of information on properties Materials.

I .INTRODUCTION

1. Identify the properties of materials

1.1 Different materials possess different properties in varying degree and therefore behave in different ways under given conditions. These principal properties of materials which are importance to the engineer in selecting materials can be broadly divided into:

- Physical Properties (density, specific heat, melting and boiling point, thermal expansion and conductivity, electrical and magnetic properties etc)
- Chemical Properties (Oxidation, corrosion, flammability, toxicity, etc)
- Mechanical Properties (strength, toughness, hardness, ductility, elasticity, fatigue and creep etc)

1.2 Physical properties of materials

These properties concerned with such properties as melting, temperature, electrical conductivity, thermal conductivity, density, magnetic properties, etc. It is extremely important to be familiar with these during product design, since choice of material affects all aspects of a product from cost, function during its expected life, aesthetics, size, shape, manufacturability etc. From the perspective of this course, physical properties of the material affect the choice of manufacturing process we can use economically. For example, a very common manufacturing process to make

Complex and delicate shapes are Electro-Discharge Machining (EDM) – which can only be used on materials that are electrical conductors; hence we cannot use EDM on most ceramics or composites. Similarly, ceramics are often refractory (don’t melt even at very high temperature), so they require different joining processes than metals, which can usually be welded. The more important of these properties will be considered as follows:

- **Density**

Density is defined as mass per unit volume for a material. The derived unit usually used by engineers is the kg/m3. Relative density is the density of the material compared with the density of the water at 4˚C. The formulae of density and relative density are:

$$density\ (\rho) = \frac{mass\ (M)}{Volume\ (V)}$$

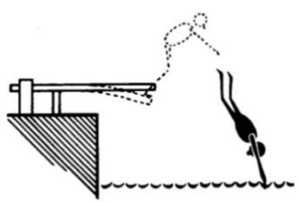
$$Relative\ density\ (d) = \frac{Density\ of\ material}{Density\ of\ pure\ water\ at\ 4^0C}$$

1.3 MECHANICAL PROPERTIES

Strength, hardness, toughness, elasticity, plasticity, brittleness, and ductility and malleability are mechanical properties used as measurements of how metals behave under a load. These properties are described in terms of the types of force or stress that the metal must withstand and how these are resisted

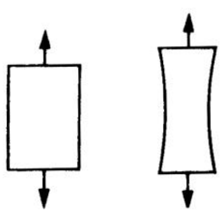
- **Elasticity:**

Is the ability of a metal to return to its original shape after being distorted. Properly heat-treated springs are good examples of elastic materials.



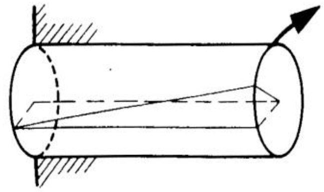
- **Ductility:**

Is the ability of a metal to be permanently deformed without breaking. Metals such as copper and machine steel, which may be drawn into wire, are ductile materials



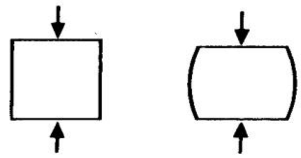
- **Tensile Strength:**

The ability of material to resist fracture under tensile load.



- **Compressive Strength:**

The ability of a material to withstand heavy compressive load.

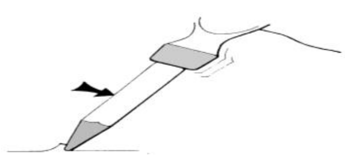


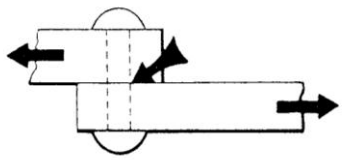
- **Brittleness:**

Is the property of a metal that allows no permanent distortion before breaking. Cast iron is a brittle metal; it will break rather than bend under shock or impact.

- **Toughness:**

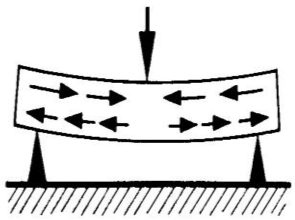
Is the ability of metals to withstand shock or impact. Toughness is the opposite of brittleness.





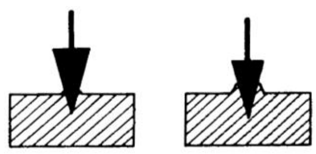
Shear Strength:

The ability of a material to resist fracture under shear load.



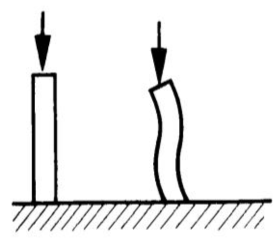
Flexural Strength:

The ability of a metal to resist under flexural force



Hardness:

The ability of metal to withstand abrasion or penetration.



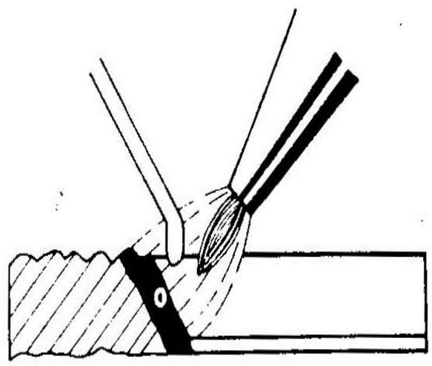
Collapsing Stress:

The ability of a metal with a slim form to resist **axial** directed force.

1.5 Manufacturing technological properties:

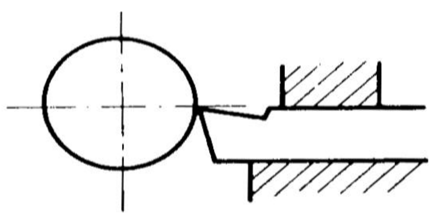
- ❖ **Weld ability:**

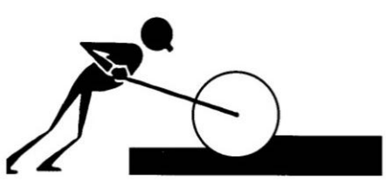
Means the ability to weld two metals together. The grade of weldability depends on the **content of carbon. Steels** with a content of max. 0.22% are more or less good weldable.



- **Mach inability:**

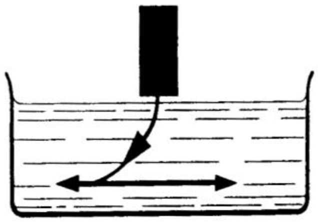
Indicates how easy or difficult materials can be machined.





Malleability:

Is the property of metals that allows it to be hammered or rolled into other sides and shapes.



Harden ability

Is the property of iron metals that allows it to increase the hardening through structural transformations.

1.6 Effects of Mechanical and thermal process on Materials

- This process is generally performed on a metal held at such a temperature that the metal does not work-harden. A few metals e.g., Pb and Sn (since they possess low crystallization temperature) can be hot worked at room temperature.
- Raising the metal temperature lowers the stresses required to produce deformations and increases the possible amount of deformation before excessive work hardening takes place.
- Hot working is preferred where large deformations have to be performed that do not have the primary purpose of causing work hardening.
- Hot working produces the same net results on a metal as cold working and annealing. It does not strain harden the metal.
- In hot working processes, compositional irregularities are ironed out and nonmetallic impurities are broken up into small, relatively harmless fragments, which are uniformly dispersed throughout the metal instead of being concentrated in large stress-raising metal working masses.
- Hot working such as rolling process refines grain structure. The coarse columnar dendrites of cast metal are refined to smaller equaled grains with corresponding improvement in mechanical properties of the component.
- Surface finish of hot worked metal is not nearly as good as with cold working, because of oxidation and scaling.

- One has to be very careful as regards the temperatures at which to start hot work and at which to stop because this affects the properties to be introduced in the hot worked metal.
- Too high a temperature may cause phase change and overheat the steel whereas too low temperature may result in excessive work hardening.
- Defects in the metal such as blowholes, internal porosity and cracks get removed or welded up during hot working.
- During hot working, self-annealing occurs and recrystallization takes place immediately following plastic deformation. This self-annealing action prevents hardening and loss of ductility.

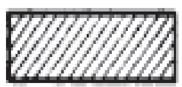
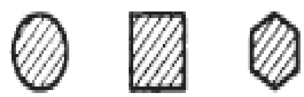
- **Cold working process increases**:
  - Ultimate tensile strength
  - Yield strength
  - Hardness
  - Fatigue strength
  - Residual stresses
  - Cold working processes decreases

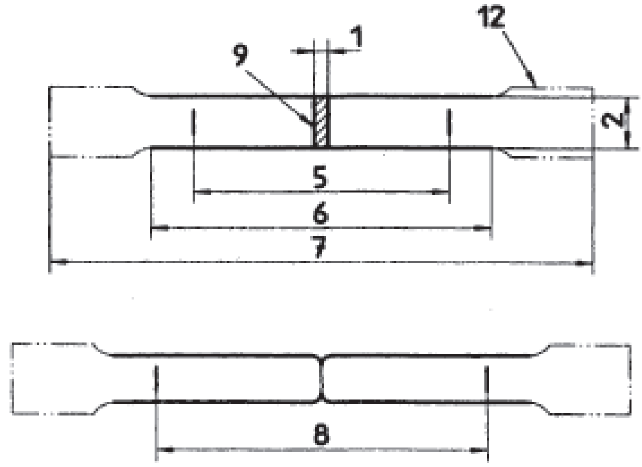
1. 6 Non-machined test pieces

If the test piece consists of an unmachined length of the product or of an unmachined test bar, the free length between the grips shall be sufficient for gauge marks to be at reasonable distance from the grips (see annexes A and D}. As-cast test pieces shall incorporate a transition radius between the gripped ends and the parallel length. The dimensions of this transition radius are important and it is recommended that they be defined in the product standard. The gripped ends may be of any shape to suit the grips of the testing machine. The parallel length (Lc) shall always be greater than the original gauge length (Lo).

Types the main types of test piece are defined in annexes A to D according to the shape and type of product, as shown in table 2. Other types of test piece can specify in product standards.

Table 2 — Main types of test piece

Type of product		Corresponding annex
Sheets — Flats  with a thickness in millimetres of	Wire — Bars — Sections  with a diameter or side in millimetres of	
0,1 ≤ thickness < 3	—	A
—	< 4	B
≥ 3	≥ 4	C
Tubes		D



NOTES
1 The shape of the test piece heads is given only as a guide.
2 See table 1 for explanation of reference numbers.

I. Material Testing

Testing of materials is necessary for many reasons, and the subject of materials testing is very broad one. Some of the purposes for the testing of materials are:

- To determine the quality of a material. This may be one aspect of process control in production plant.
- To determine such properties as strength, hardness, and ductility.
- To check for flaws within a material or in a finished component.
- To assess the likely performance of the material in a particular service condition.

It is obvious that there is not one type of test that will provide all the necessary information about a material and its performance capabilities, and there are very many different types of test that have been devices for use in the assessment of materials. One of the most widely tests is the tensile test to destruction. In this type of test a test-piece of standard dimensions is prepared, and this is then stressed in an axial tension. Other tests that are often used for the determination of strength data are compression, torsion, hardness, creep and fatigue tests. With the exception of harness tests, these are all test of a destructive nature and they normally require the preparation of test-pieces to certain standard dimensions. For the detection of flaws or defects within part-processed stock material, or within finished components, there are several non-destructive test techniques available. In addition, there are many special tests that have been devised for the purpose of assessing some particular quality of material, or for obtaining information on the possible behavior of component or assembly in service.

In spite of the properties of materials where introduced, then the composition, processing and heat treatment of a range of metallic adnoun-metallic materials widely used by the engineer have been described, we should more be able to understand the problems and techniques associated with the testing of materials properties because they can be, nonetheless, useful to the designer, fabricator, and research worker, as follow:

1. TESTING OF METALS

Metal testing is accomplished for the purpose of for estimating the behavior of metal under loading (tensile, compressive, shear, torsion and impact, cyclic loading etc.) of metal and for providing necessary data for the product designers, equipment designers, tool and die designers and system designers. The material behavior data under loading is used by designers for design calculations and determining whether a metal can meet the desired functional requirements of the designed product or part. Also, it is very important that the material shall be tested so that their mechanical properties especially their strength can be assessed and compared. Therefore the test procedure for developing standard specification of materials has to be evolved. This necessitates both destructive and non-destructive testing of materials.

Destructive tests of metal include various mechanical tests such as tensile, compressive, hardness, impact, fatigue and creep testing. A standard test specimen for tensile test is shown in Fig. 14 Non-destructive testing includes visual examination, radiographic tests, ultrasound test, liquid penetrating test and magnetic particle testing.

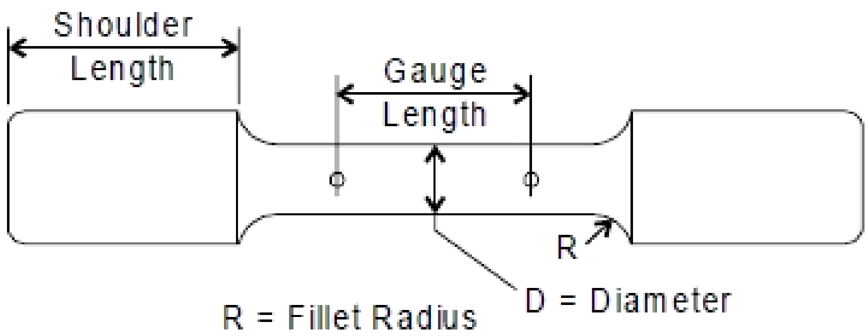


Figure 25: materials for tensile test

- **Tensile test**

A tensile test is carried out on standard tensile test specimen in universal testing machine.

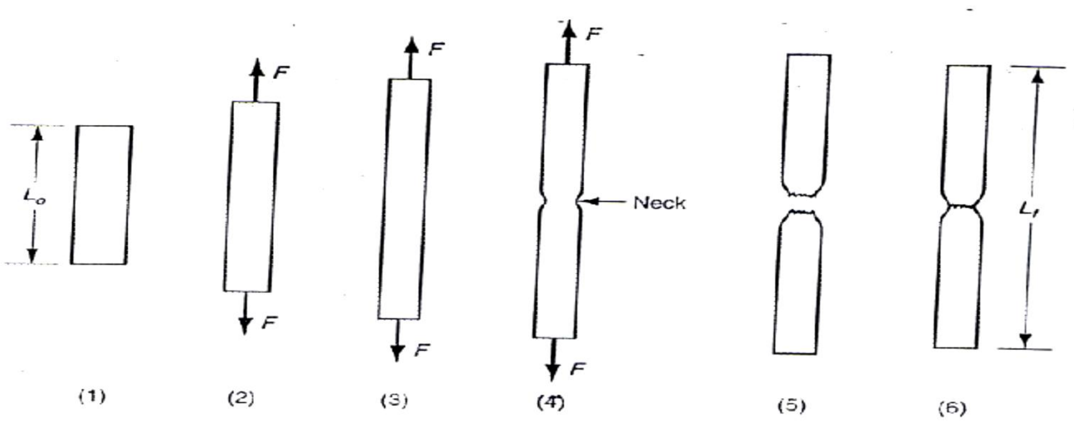


Figure 26: Typical progress of a tensile test: (1) beginning of test, no load; (2) uniform elongation and reduction of cross-sectional area; (3) continued elongation, maximum load reached; (4) necking begins, load begins to decrease; and (5)fracture. If pieces are put back together as in (6), final length can be measured.

Let's now look at Figure 20 In this figure, the *gauge length (L_0)* is the length over which the elongation of the specimen is measured. The *minimum parallel length (L_c)* is the minimum length over which the specimen must maintain a constant cross-sectional area before the test load is applied. The lengths L_o, L_c, L_i. and the cross-sectional area *(A)* are all specified in BS 18.

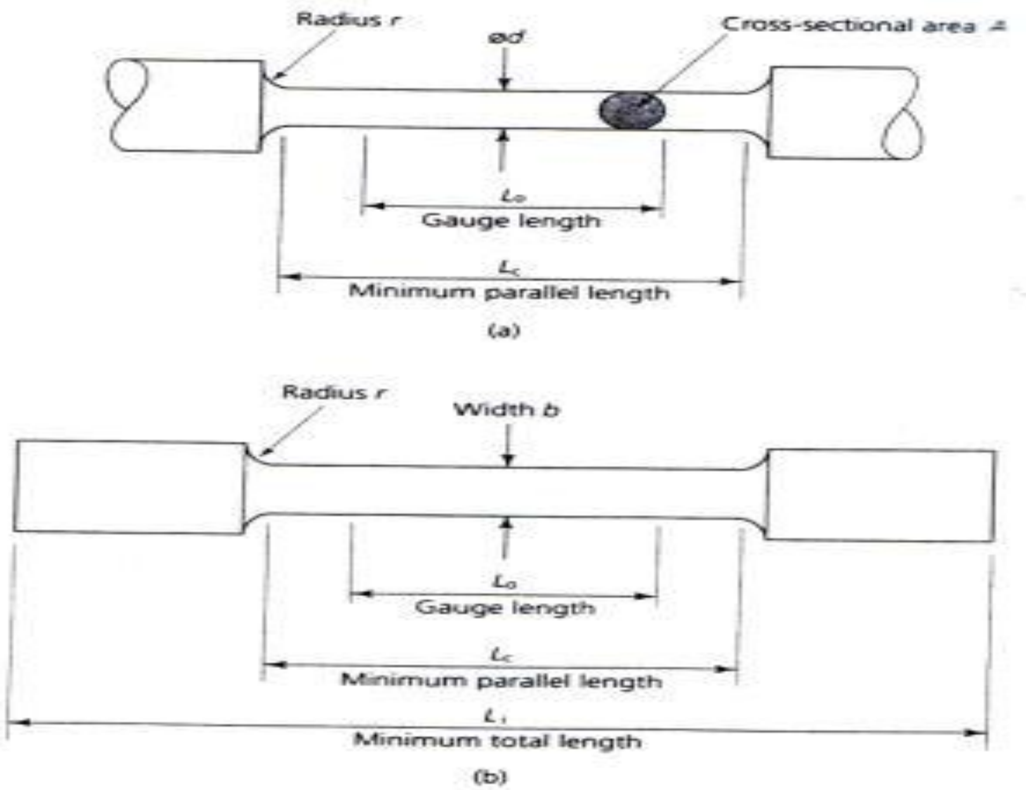


Figure 27: Properties of tensile test specimens: (a) cylindrical; (b) flat

The elongation obtained for a given force depends upon the length and area of the cross-section of the specimen or component, since:

$$\boldsymbol{Elongation} = \frac{\text{appliedforce} \times \text{L}}{\text{E} \times \text{A}}$$

WhereL = length

A = cross-sectional area

E = elastic modulus

Therefore, if the ratio [L**/A]** is kept constant (as it is in a proportional test piece), and *E* remains constant for a given material, then comparisons can be made between elongation and applied force for specimens of different sizes.

Let's now look at the sort of results we would get from a typical tensile test on a piece of annealed low-carbon steel. The load applied to the specimen and the corresponding extension can be plotted in the form of a graph, as shown in Figure 28.

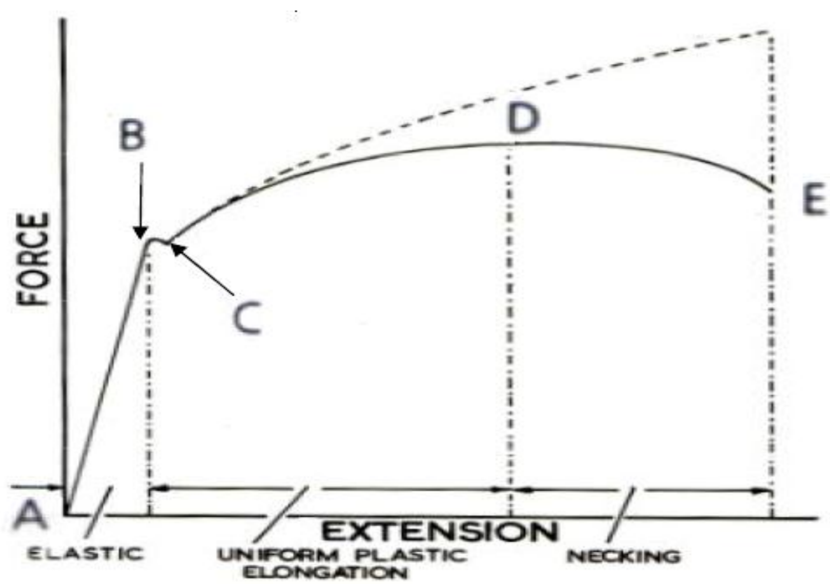


Figure 28: Load-extension curves for low-carbon steel

From A to B the extension is proportional to the applied load. Also, if the load is removed the specimen returns to its original length. Under these relatively lightly loaded conditions the material is showing *elastic* properties.

- From B to C it can be seen from the graph that the metal suddenly extends with no increase in load. If the load is removed at this point the metal will not spring back to its original length and it is said to have taken a *permanent set.* Therefore, B is called "limit of proportionality ", and if the force is increased beyond this point a stage is reached where a sudden extension takes place with no increase in force. This is known as the "yield *point"* C.

The *yield stress* is the stress at the yield point; that is, the load at B divided by the original cross-section area of the specimen. Usually, a designer works at 50 per cent of this figure to allow for a 'factor of safety'.

- From C to D extension is no longer proportional to the load, and if the load is removed little or no spring back will occur. Under these relatively greater loads the material is showing *plastic* properties.
- The point D is referred to as the 'ultimate tensile strength' when referred extension graphs or the 'ultimate tensile stress' (UTS) when referred to stress-strain graphs. The ultimate tensile stress is calculated by dividing the load at D by the original cross-sectional area of the specimen. Although a useful figure for comparing the relative strengths of materials, it has little practical value since engineering equipment is not usually operated so near to the breaking point.
- From D to E the specimen appears to be stretching under reduced load conditions. In fact the specimen is thinning out (necking) so that the 'load per unit area' or stress is actually increasing. The specimen finally work hardens to such an extent that it breaks at E.
- In practice, values of load and extension are of limited use since they apply to one particular size of specimen and it is more usual to plot the stress-strain curve. Stress and strain are calculated as follows:

$$\boldsymbol{Sress}\ (\boldsymbol{\sigma}) = \frac{\boldsymbol{Load}\ (\boldsymbol{F})}{\boldsymbol{Area}\ (\boldsymbol{A})}$$

$$\boldsymbol{Srain}\ (\boldsymbol{\varepsilon}) = \frac{\boldsymbol{extension}}{\boldsymbol{originallength}}$$

- **Compression Test**

Compression test is reverse of tensile test. This test can also be performed on a universal testing machine. In case of compression test, the specimen is placed bottom crossheads. After that, compressive load is applied on to the test specimen. This test is generally performed for testing brittle material such as cast iron and ceramics etc. Fig. 22 shows the schematic compression test set up on a universal testing machine. The following terms have been deduced using figures pertaining to tensile and compressive tests of standard test specimen.

Hook's Law

Hook's law states that when a material is loaded within elastic limit (up to proportional limit), stress is proportional to strain.

Strain

Strain is the ratio of change in dimension to the original dimension.

Tensile Strain

The ratio of increase in length to the original length is known as tensile strain. Compressive Strain The ratio of decrease in length to the original length is known as compressive strain.

Modulus of Elasticity

The ratio of tensile stress to tensile strain or compressive stress to compressive strain scaled modulus of elasticity. It is denoted by E. It is also called as Young's modulus of elasticity.

E = Tensile Stress/Tensile Strain

Modulus of Rigidity The ratio of sheer stress to shear strain is called modulus of rigidity. It is denoted by G.

G = Shear Stress/Shear Strain

Bulk Modulus

The ratio of direct stress to the volumetric strain (ratio of change in volume to the original volume is known as volumetric strain) is called Bulk modulus (denoted by K).

K = Direct stress/volumetric strain

Linear and Lateral Strain

When a body is subjected to tensile force its length increases and the diameter decreases. So when a test specimen of metal is stressed, one deformation is in the direction of force which is called linear strain and other deformation is perpendicular to the force called lateral strain.

Poisson’s Ratio

The ratio of lateral strain to linear strain in metal is called Poisson’s ratio. Its value inconstant for a particular material but varies for different materials.

Proof Resilience

The maximum amount of energy which can be stored in an elastic limit is known as proof resilience.

Modulus of Resilience

The proof resilience per unit volume of a material is modulus of resilience or elastic toughness.

Because of the presence of submicroscopic cracks, brittle materials are often weak in tension, as tensile stress tends to propagate those cracks which are oriented perpendicular to the axis of tension. The tensile strengths they exhibit are low and usually vary from sample to sample. These same materials can nevertheless be quite strong in compression. Brittle materials are chiefly used in compression, where their strengths are much higher. Schematics diagram of a typical compression test result is shown in figure23.

Figure 23 Tensile and compressive engineering stress-strain curves for gray cast iron and concrete

Ductility testing

The percentage elongation, as determined by the tensile test, has already been discussed as a measure of ductility. Another way of assessing ductility is a simple bend test. There are several ways in which this test can be applied, as shown in figure 24. The test chosen will depend upon the ductility of the material and the severity of the test required.

- ***Close bend test*** the specimen is bent over on itself and flattened. No allowance is made for spring back, and the material is satisfactory if the test can be completed without the metal tearing or fracturing. This also applies to the following tests.
- ***Angle bend test*** the material is bent over a former and the nose radius of the former and the angle of bend (θ˚) are fixed by specification. Again no allowance is made for spring back.
- ***180 ˚ bend test*** this is a development of the angle bend test using a flat former as shown. Only the nose radius of the former is specified.

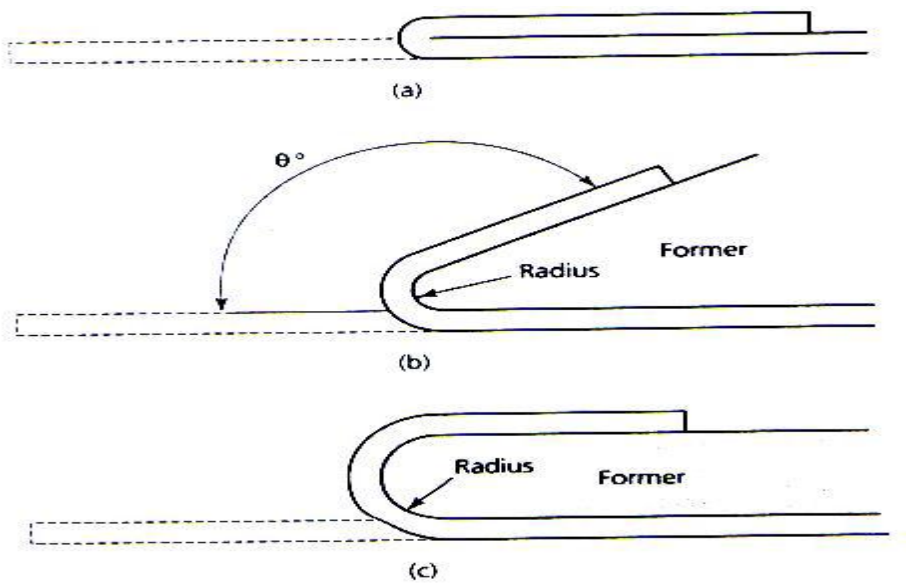


Figure 24 Bend tests: (a) close bend; (b) angle bend; (c) 180 C bend

Impact testing (toughness testing) Impact tests consist of striking a suitable specimen with a controlled blow and measuring the energy absorbed in bending or breaking the specimen. The energy value indicates the toughness of the material under test.

Figure 25 shows a typical impact testing machine which has a hammer that is suspended like a pendulum, a vice for holding the specimen in the correct position relative to the hammer and a dial for indicating the energy absorbed in carrying out the test in joules (J).

When the heavy pendulum, released from a known height, strikes and breaks the sample before it continues its upward swing. From knowledge of the mass of the pendulum and the difference between the initial and final heights, the energy absorbed in fracture can be calculated, as shown in figure 26 the schematic drawing of the impact test machine.

Figure 14 Typical impact testing machine

Figure 26 Schematic drawing of standard impact-testing apparatus Figure 27 shows how a piece of high carbon steel rod will bend when in the annealed condition, after hardening and lightly tempering, the same piece of steel will fracture when hit with different hammer.

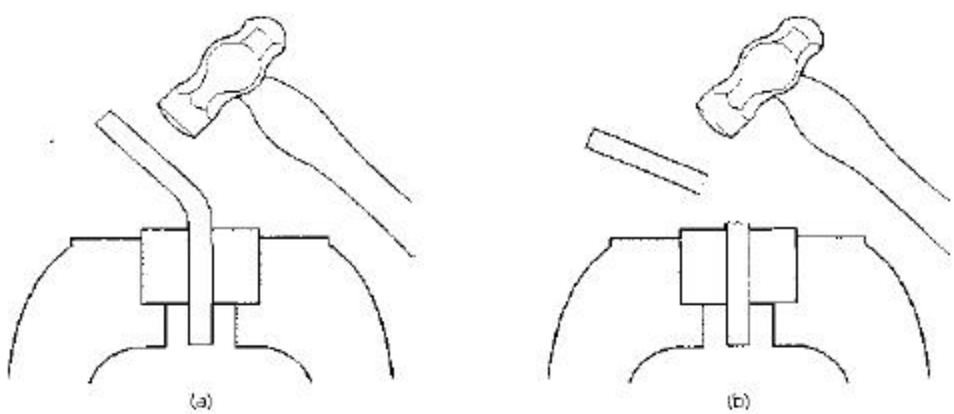


Figure 27 Impact loading: (a) a rod of high-carbon (1.0%) steel in the annealed (soft) condition will bend struck with a hammer (UTS 925 Map); (b) after hardening and lightly

tempering, the same piece steel will fracture when hit with a hammer despite It's UTS having increased to 1285 Map

There are several types of the impact tests and the most famous types the Izod test.In the Izod test, a 10mm square, notched specimen is used, it is preferred to use a specimen that have a more than one or two and even three notched in the same specimen. The striker of the pendulum hits the specimen with a kinetic energy of 162.72 J at a velocity of 3.8m/s. Figure28 shows details of the specimen and the manner in which it is supported.

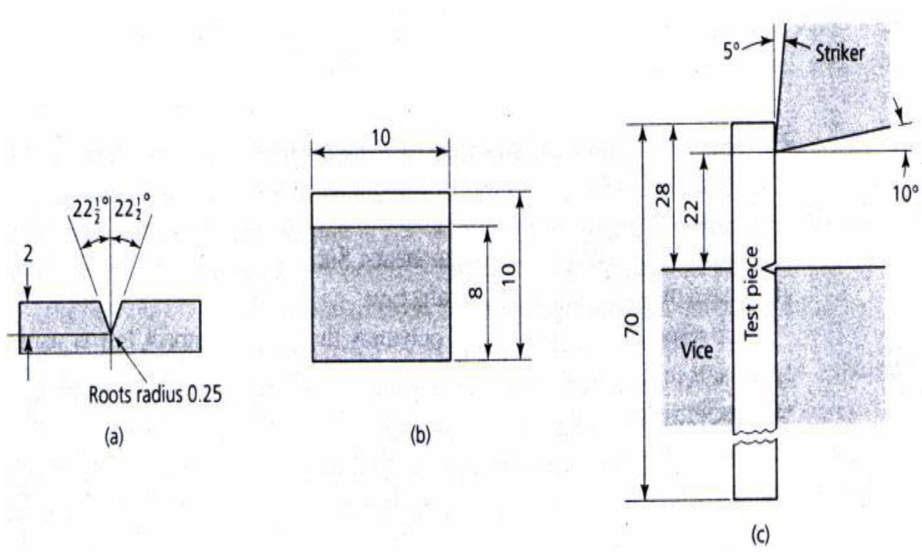


Figure 28 Izod test (a/I dimensions in millimeters); (a) detail of notch; (b) section of test piece (at notch); (c) position of strike

Since test use a notched specimen, useful information can be obtained regarding the resistance of the material to the spread of carrack which may originate from a point of stress concentration such as sharp comers, undercuts, sudden changes in section, and machining marks in stressed components. Such points of stress concentration should be eliminated during design and manufacture.

A second type of impact test is the Chirpy test. While in the Izod test the specimen is supported as a cantilever (Vice), but in the Chirpy test it is supported as a beam. It is struck with a kinetic energy of 298.3 J at velocity of 5m/s. The Chary impact test is usually use for testing the toughness of polymers. Figure 29 shows details of the Chirpy tes: manner in which it is supported.

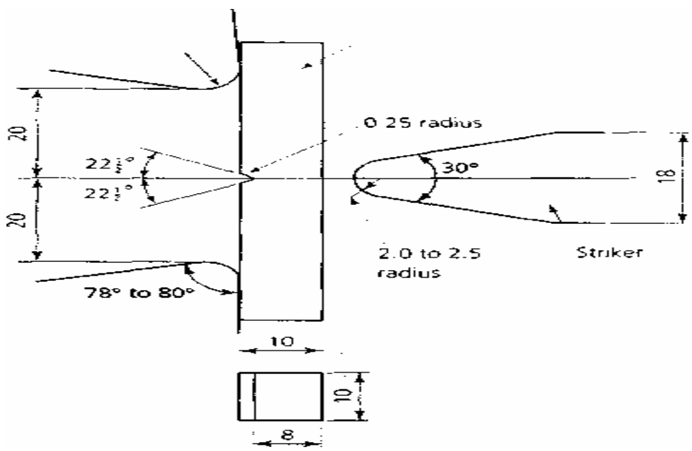


Figure 29 Chirpy test (all dimensions in millimeters) ***Testing of Fatigue***

Material subjected to static and cyclic loading, yield strength is the main criterion for product design. However for dynamic loading conditions, the fatigue strength or endurance limit ofa material is used in main criteria used for designing of parts subjected to repeated alternating stresses over an extended period of time. Fig 30 shows a fatigue test set up determining the fatigue strength of material. The fatigue test determines the stresses which a sample of material of standard dimensions can safely endure for a given number of cycles. It is performed on a test specimen of standard metal having a round cross-section, loaded at two points as a rotating simple beam, and supported at its ends.

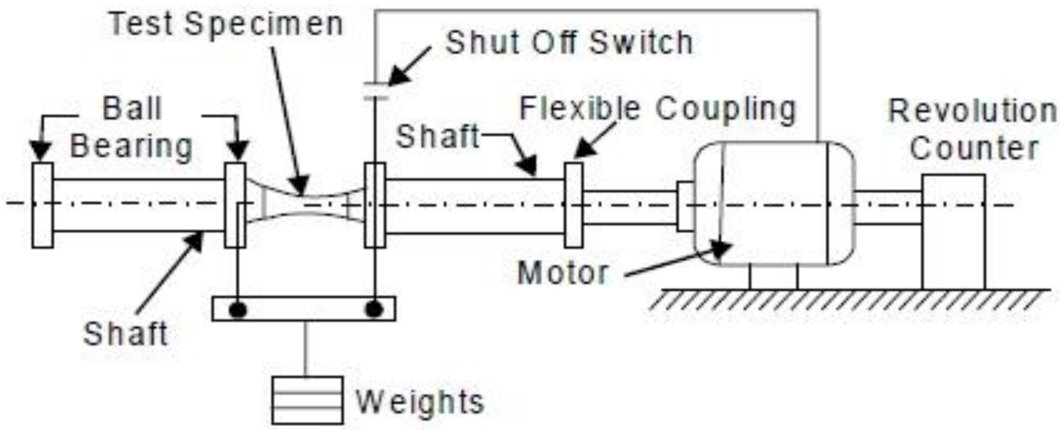


Figure 30 Schematic fatigue test setup

Testing of Creep

Metal part when is subjected to a high constant stress at high temperature for a longer period of time, it will undergo a slow and permanent deformation (in form of a crack which may further propagate further towards creep failure) called creep. Creep is time dependent phenomena of metal failure at high constant stress and at high temperature such subjecting of at steam turbine blade. A schematic creep testing setup is shown in Figure31 Test is carried out up to the failure of the test specimen. A creep curve for high temperature and long time creep is shown in Fig. 32 The curve shows different portions of the primary secondary and tertiary creep which ends at fracture in metals.

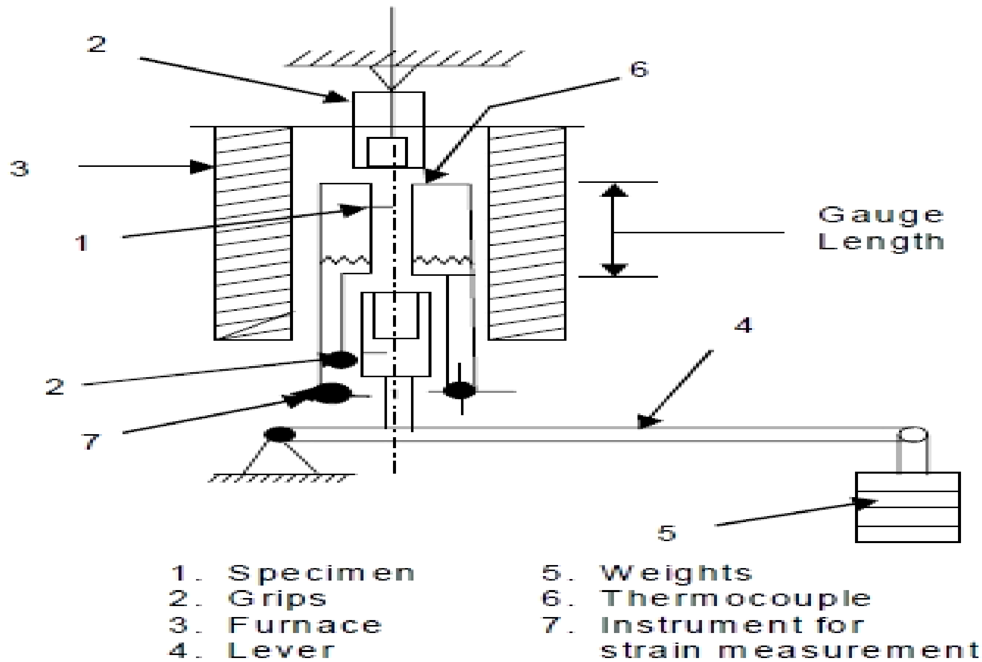


Figure 31Schematic creep testing setup

1.4 Purpose calibrating materials and instruments

- Benefit from our many years of experience in calibrating testing systems at Germany's biggest testing laboratory. Our calibration service and laboratory have been accredited by the German Calibration Service (DKD(since 1994 and DAkkS-accredited since 2013. This shows that we clearly satisfy the requirements for testing and calibration laboratories as defined by DIN EN ISO/IEC 17025—your guarantee for accurate, independent, and efficient calibration services

Benefit for calibration

- Comprehensive calibration portfolio
- Extensive experience and expertise gained from over 10,000 calibrations a year
- Highly accurate test results with low measurement uncertainty
- Large number of measuring points to cover the entire force and measurement ranges

- Inspection of all materials testing machines and instruments as part of calibration
- Adjustment where required free of charge
- Fast, flexible service provided by our many expert service technicians
- Calibration of testing systems made by other manufacturers
- Neutrality, efficiency, and accuracy
- Internationally recognized calibration certificates

Reliable test results

We calibrate more accurately than the standard requires The range for calibration depends on The type of load cell on the materials testing machine, the machine electronics, the display resolution. For materials testing machines with high precision (HP) series load cells, the range is starts at 0.2% of nominal force; for other types the range starts at 0.4%. In this way we cover the full measurement range and ensure maximum result accuracy. The standards require a calibration range of 20 – 100% of the nominal load and five calibration stages. A ZwickRoell calibration certificate consists of 11 calibration stages.

1.5 Salient Features of Digital system:

- User friendly system
- 21 X 8 Line Display
- Keyboard Entry for Serial No, Batch No, Date Time
- Ball diameter / Load Selection: 2.5mm/187.5kgf, 5mm/250kgf, 5mm/750kgf, 10mm/500kgf, 10mm/1000kgf ,10mm/3000kg
- Ball Type Selection : Tungsten /Steel
- User can set zero and move cursor for X and Y measurement
- Direct BHN reading after pressing BHN key.
- Optional conversion result facility for other scales(Vickers HV, Knops HK, Tensile Strength KSI, Micro ficial WM

1.6 Calibration may be used for:

- a new instrument: - We must make sure the instrument is providing accurate Indication
- after an instrument has been repaired or modified
- when a specified time period has elapsed
- when a specified usage (operating hours) has elapsed
- after an event, for example
- after an instrument has had a shock, vibration, or has been exposed to an

Adverse condition which potentially may have put it out of calibration or damage it sudden changes in weather

1.7 General

Visual, dimensional and, as appropriate, non-destructive examinations are to be performed by the manufacturer on the materials supplied prior to delivery, as required. The general provisions indicated specific requirements for the various products as specified in the relevant Articles of this Section apply. On-destructive examinations may be required by the Surveyor

When deemed necessary.

- Thickness tolerances of steel plates and wide flats the tolerances on thickness of a given product are defined as:
- minus tolerance is the lower limit of the acceptable range below the nominal thickness
- plus tolerance is the upper limit of the acceptable range above the nominal thickness. The requirements for minus tolerances on nominal thickness are indicated in the Articles relevant to the various products. The plus tolerance on no thickness is to be in accordance with a recognized national or international standard. The tolerances on nominal thickness are not applicable to

Self-Check -4	Written Test

Direction-Choose the best answer

1. Is the ability of a metal to be permanently deformed without breaking?
   A. Hardness C. brittleness
   B. Ductility D.none
2. Is the property of metal that allows no permanent distortion before breaking?
   A. Toughness C. hardness
   B. brittleness D.None
3. The ability of metal to withstand abrasion or penetration
   A. hardness C. toughness
   B. brittleness D.None
4. Is the property of metals that allows it to be hammered in to other side of shapes
   A. ductility C. toughness
   B. malleability D .None

Note: Satisfactory rating – 2 and 3 points Unsatisfactory - below 2 and 43points

You can ask you teacher for the copy of the correct answers.

Score = ____________

Rating: _____________

Answer Sheet

Name: ___________________________ Date: _______________

Information Sheet-5	Selecting appropriate sources of information on Materials Safety Data Sheets (MSDS).

I NTRODUCTION

1.1 Introduction to Material Safety Data Sheet

A material safety data sheet is a technical document which provides detailed and comprehensive information on a controlled product related to:

- health effects of exposure to the product
- hazard evaluation related to the product's handling, storage or use
- measure to protect workers at risk of exposure
- Emergency procedures.

The data sheet may be written, printed or otherwise expressed, and must meet the availability, design and content requirements of WHMIS legislation. The legislation provides for flexibility of design and wording but requires that a minimum number of categories of information be completed and that all hazardous ingredients meeting certa1.2 The Purpose of the Data Sheet

The data sheet is the second element of the WHMIS information delivery system and is intended to supplement the alert information provided on labels. The third element of the system is the education of employees in hazard information on controlled products, including instruction in the content and significance of information on the MSDS.
in criteria be listed subject to exemptions granted under the Hazardous Materials

- **Material Safety Data Sheet Content**

A supplier material safety data sheet must provide at least nine categories or sections of content and approximately sixty items of information distributed among those categories. An MSDS must be reviewed at least every three years. The categories must have the following similar headings:

Hazardous Ingredients

- The chemical names and concentrations concerning the hazardous ingredients
- The LD 50 and LC50 indicate the short term toxic potential
- CAS number which is useful in locating more information especially if the product is known by numerous names\

.Preparation Information

- The name address and telephone number of who prepared the MSD
- The date the MSDS was prepared
- If more than three years old, it must be updated

Product Information

- Identifies the product by the name on the supplier label
- Provides the chemical name, family and formula (including molecular weight)
- Lists the product identifiers, manufacturer and supplier names, addresses and emergency telephone numbers

.Physical Data

- The state it is in e.g. liquid
- The odor and appearance of the product
- The specific gravity, vapors density, evaporation rate, boiling point and the freezing point
- The vapors pressure, the higher the concentration the higher the possible air concentration
- The dour threshold, which is the lowest airborne concentration of a chemical that can be perceived by smell
- The pH reflecting the corrosive or irritant nature of the product

Fire and Explosion Hazard

- The temperature and conditions that can cause the chemical to catch fire or explode
- Means of extinction including the type of fire extinguisher required

Personal Protective Equipment required for fire fighting

- **Dust Skin contact:**

Immediately remove any metal fragments or pieces that get under the skin. Wash well with plenty of soap and water following any contact with metal particles. Remove any contaminated clothing and launder before reuse. Seek medical attention if irritation develops.

- **Eye contact:**

Avoid getting finely divided particles in the eyes. Flush immediately with plenty of luke-warm water, keeping eyelids open. Seek medical attention if symptoms persist.

- **Ingestion:**

Welding electrodes are not hazardous, but should be kept out of the mouth. Finely divided particles may be easily ingested along with food, drink or smoking. If large quantities ingested, seek medical advice., fumes SECTION 6: Accidental release measures

- Personal precautions, protective equipment and emergency procedures

Not applicable to solid metal/welding electrodes. Do not inhale dust.

- **Environmental precautions**

Do not allow to enter sewers/ surface or ground water. Collect powder using a vacuum cleaner or by gentle sweeping to keep dust away from drains, surface and ground water. Prevent particulates from entering watercourses or drains. Avoid formation of dust clouds.

- **Methods and materials for containment and cleaning**

Collect powder using a vacuum cleaner or by gentle sweeping. Pick up mechanically. No danger : Handling and storage

- **Precautions for safe handling**

Working areas should be provided with extraction. Factories should be kept clean to avoid any unnecessary contamination. Do not to eat, drink and smoke in work areas and wash hands/shower when leaving the working areas. No special precautions necessary for solid electrodes other than normal physical handling techniques. Prevent formation of dust. Extraction should be used when working with particulate material (dust, fumes, mist). Avoid prolonged inhale Exposure Controls

Always check the applicability of any protective equipment with your supplier.

- **Eye/face protection**

Always wear eye protection when handling dusts and other particulates, eg safety glasses with side protection, safety goggles or visor.

- **Skin protection**

Always wear protective clothing when handling dusts and other particulates.

- **Hand protection**

Wear hand protection, e.g. leather gloves when handling electrodes with sharp edges to avoid cuts. Always wear disposable nitrile or vinyl gloves when handling particulate material to avoid skin contact. Where necessary wear the disposable gloves under work gloves to protect against both types of hazard.

1.2 Physical and chemical properties

Information on basic physical and chemical properties

- Form: Solid
- Color: Grey
- Odor: Odorless Self-igniting: Product is not self igniting.
- Danger of explosion: Product does not present an explosion hazard. Solubility in
- Mobility with water: Insoluble. Other information methods No Waste treatment methods
- Dispose in accordance with appropriate government regulations.European waste catalogue:

12 01 13 welding wastes 12 01 20 spent grinding bodies and grinding materials containing dangerous substances recommendation: Disposal must be made according to official regulations other physical or

- Regulatory information

Safety, health and environmental regulations/legislation specific for the substance or mixture prepared according to EU Directives 1907/2006 (REACH) & 1272/2008 (CLP). Classifications mentioned in table 3.2 concerns substances in their crushed form. Welding electrodes do not require labeling under current chemical product classification and labeling regulations. The product is not subject to identification regulations under

EU Directives and the Ordinance on Hazardous Materials (German GefStoffV). National regulations: Water hazard class 1 (Self-assessment): slightly hazardous for water. (Exception: Cal die Weld which is generally not hazardous for water.)

- Chemical Safety Assessment

No chemical safety assessment has been carried out for the product

SECTION 16: Other information

16.1 Other technical parameters are necessary for the welding products

- General Fire Hazards:

As shipped, this product is nonflammable. However, welding arc and sparks can ignite combustibles and flammable products. Read and understand American National Standard Z49.1, "Safety In Welding, Cutting and Allied Processes" and National Fire Protection Association NFPA 51B, "Standard for Fire Prevention During Welding, Cutting and Other Hot Work" before using this product.

- Handling and storage

For safe handling: Keep formation of airborne dusts to a minimum. Provide appropriate exhaust ventilation at places where dust is formed. Read and understand the manufacturer's instruction and the precautionary label on the product. Refer to Lincoln

Safety Publications at STORAG Store in closed original container in a dry place. store away from incompatible materials. Store in accordance with local/regional/national regulations.

- Key literature references and sources for data

This information is based on the manufacturer's MSDS and European laws. Department issuing MSDS at UTP: QS department, contact: Herr Wrangler. Contact supplier for detailed reports of sources.

- Full text of Hazard statements used
- H225 Highly flammable liquid and vapor
- H318 Causes serious eye damage
- H335 May cause respiratory irritation

Accidental release measures

- Personal precautions, protective equipment and emergency procedures
- Not applicable to solid metal/welding electrodes. Do not inhale dust.
- Environmental precautions
- Do not allow to enter sewers/ surface or ground water. Collect powder using a vacuum cleaner or by gentle sweeping to keep dust away from drains, surface and ground water. Prevent particulates from entering watercourses or drains. Avoid formation of dust clouds.
- Methods and materials for containment and cleaning

Collect powder using a vacuum cleaner or by gentle sweeping. Pick up mechanically. No dangerous substances are released.2 Harmful to aquatic life with long lasting effects

Self-Check -5	Written Test

Direction-Choose the best answer

1 A material and technical document which provide detailed and comprehensive information on controlled product

A. material safety data sheet
B. manufacturing data sheet
C. Information data sheet
D. none

2 collect powder using cleaner or by gentle sweeping to keep dust away from drains

A. environmental precaution
B. precaution for safe handling
C. Ingestion
D.None

3. Working areas should be provided with extraction. Factories should be kept clean to avoid any unnecessary contamination. Do not to eat, drink and smoke in work areas

A. environmental precaution
B. precaution for safe handling
C. Ingestion
D.None

4. Where necessary wear the disposable gloves under work gloves to protect against both types of hazard.

A. environmental precaution
B. Skin protection
C Hand protection
D .None

Note: Satisfactory rating – 2 and 3 points Unsatisfactory - below 2 and 43points

You can Answer Sheet

Score = ____________

Rating: _____________

Name: ___________________________ Date: _______________

OPERATION SHEET 2	**Determining correct materials components**.

Preparing material types and equipment for metallurgy

Steps 1- Wear PPE

Steps 2- Select required material for the work

Steps 3- using appropriate tools and equipment

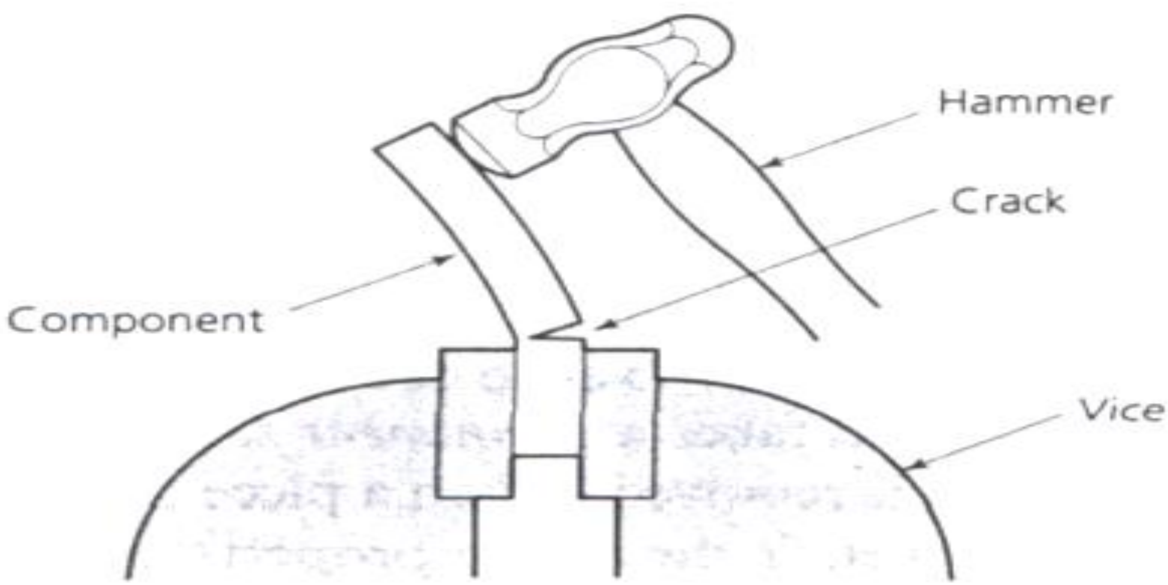
Steps 4**-** cut the work pieces high carbon steel

Steps 5- tight the vice and bend (Ø 16,20cm)

Steps 6- the impact load as shown.

Steps 7- bend without break under the impact of the hammer

Steps 8- the rod made glass then it will broken by impact loading



LAP Test	Practical Demonstration

Name: ________________________________ Date: _________________

Time started: ___2:00_am ________________ Time finished: ___4:00______________

Instructions: Given necessary templates, tools and materials you are required to perform to make simple split pattern in the following tasks within 2hour.

Task 1 Perform to PPE.

Task 2 Perform required pattern material.

Task 3 Perform using appropriate tools and equipment

Task 4 Perform cut the work pieces high carbon steel.

Task 5 Perform tight the vice and bend (Ø 16,20cm) .

Task 6 Perform the impact load as shown

Task 7 Perform the rod made glass then it will broken by impact loading

Step 8 Perform the use of 5s.

Operation Sheet .1	Performing tension testing

The purpose of this operation is to give trainees experience in measuring various Strength parameters of different metals materials.

Step 1- wear personal protective equipment PPE

Step 2- to prepare materials to be tested. A36 Hot Rolled Steel blue /black

Step 3- select required Longitudinal round Tensile test (ASTM E8) to be performed on

. Step 4- Using a micrometer, measure and record the diameter

Step 5-- Mark two gage points 2 inches apart on the specimen with a special diameter

Step-6 Place the specimen in the threaded grips and load the specimen slowly to failure Record the load and deflection for each 300kg load..

Step 7- Remove the extensometer from the specimen before fracture occurs

Step 6- Tension test data A36 Hot Rolled Steel Sketch

Initial diameter: ____________________

Diameter at failure: __________________

Distance between two gage points, initial: _____________

At failure: ___________________

LAP Test	Practical Demonstration

Name: ______________________ Date: _________

Time started: ________________ Time finished: _________

Instructions: You are required to perform the following individually with the presence of your teacher.

Step 1-peform wear personal protective equipment PPE

Step 2-perform prepare materials to be tested. A36 Hot Rolled Steel blue /black

Step 3- perform select required Longitudinal round Tensile test (ASTM E8) to be performed on

. Step 4-Perform using a micrometer, measure and record the diameter

Step 5—perform mark two gage points 2 inches apart on the specimen with a special diameter

Step-6 perform place the specimen in the threaded grips and load the specimen slowly to failure Record the load and deflection for each 300kg load..

Step 7-prform Remove the extensometer from the specimen before fracture occurs

Step 6- perform Tension test data A36 Hot Rolled Steel Sketch

Operation Sheet .1	Performing tension testing

The purpose of this operation is to give trainees experience in measuring various Strength parameters of different metals materials.

Step 1- wear personal protective equipment PPE

Step 2- select required tools and equipment.

Step 3- collect broken bricks for recycling.

Steps 4- break down these bricks until it become 10mm of crushed stone.

Steps 5- fill and compact the crushed brick aggregates for stabilizing expansive

LAP Test	Practical Demonstration

Name: ________________________ Date: __________

Time started: __________________ Time finished: __________

Instructions: You are required to perform the following individually with the presence of your teacher.

1. Prepare all the report for the test to be done by following the operation sheet

Step 1- perform select required tools and equipment.

Step 2- perform collect broken bricks for recycling.

Steps 3- perform break down these bricks until it become 10mm of crushed stone.

Steps 4- perform fill and compact the crushed brick aggregates for stabilizing exp

Steps 5- perform select required tools and equipment.

Steps 6- perform collect broken bricks for recycling ansive

Mechanics

Level-III

Learning Guide-38

Unit of Competence:	**Determine Welding Materials**
Module Title	**Determining Welding Materials**

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 3. Prepare materials and equipment for testing

Instruction Sheet	Learning Guide #38

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics:

- Selecting materials for manufacturing engineering applications
- Identifying materials for testing
- Preparing materials and equipment based on Standardized test.

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Select materials for use in given mechanical/ manufacturing engineering applications based on relevant test information•
- Classifies identified materials for testing based on relevant test information• .
- Prepare materials and equipment are prepared based on to be conducted standardized test

Learning Instructions:

1. Read the specific objectives of this Learning Guide
2. Follow the instructions described below
3. Read the information written in the information "Sheet 1, Sheet 2, Sheet 3 and Sheet 4"
4. Accomplish the "Self-check 1, Self-check t 2, Self-check 3 and Self-check 4" in page -6, 9, 12 and 14 respectively.
5. If you earned a satisfactory evaluation from the "Self-check" proceed to "Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3" in page -1

Information Sheet-1	Selecting materials for manufacturing engineering applications

1. Selecting materials for manufacturing Engineering application

Selecting materials for manufacturing engineering applications Design of an engineering component involves three interrelated problems:

- Selecting a material,
- Specifying a shape, size, weight and
- Choosing a manufacturing process.

If you getting this selection right the first time by selecting the optimal combination your design has enormous benefits to any engineering-based business. It leads to lower product costs, faster time-to-market, reduction in the number of in-service failures, and sometimes, significant advantages relative to your competition.

But to realize these benefits, engineers have to deal with an extremely complex problem. There are literally tens of thousands of materials and hundreds of manufacturing processes. No engineer can expect to know more than a small subset of this ever-growing body of information. Furthermore, there are demanding and shifting design requirements such as cost, performance, safety, risk and aesthetics (appearance), as well as environmental impact and recycle-ability.

1.2 applications and processing of metal alloys

This question asks that we list four classifications of steels, and, for each, to describe properties and cite typical applications.

- *Low-Carbon Steels*

- Properties: nonresponsive to heat treatments; relatively soft and weak; machinable and wieldable.
- Typical applications: automobile bodies, structural shapes, pipelines, buildings, bridges, and tin cans.

- Medium-Carbon Steels
  - Properties: heat treatable, relatively large combinations of mechanical characteristics.
  - Typical applications: railway wheels and tracks, gears, crankshafts, and machine parts.
- High-Carbon Steels
  - Properties: hard, strong, and relatively brittle.
  - Typical applications: chisels, hammers, knives, and hacksaw blades.
- High-Alloy Steels (Stainless and Tool)
  - Properties: hard and wear resistant; resistant to corrosion in a large variety of environments.
  - Typical applications: cutting tools, drills, cutlery, food processing, and surgical tools.
- Ferrite and austenitic stainless steels are not heat treatable since "heat treatable" is taken to mean that marten site may be made to form with relative ease upon quenching austenite from an elevated temperature.

1.3 Material Selection Basics

Why

- To make full use of the engineering materials.
- To avoid unnecessarily expensive structures.
- To avoid failures.

When

- A new product is developed.
- A product is modified and redesigned.
- Failures have occurred.

Who

- Design engineers in collaboration with materials engineers.

How

- Specify the requirements for the component.
- Transfer the requirements to materials properties.
- Find the material groups that satisfy the specification.
- Find the individual materials that satisfy the specification.
- identify the "best" materials that satisfy the specification

The basic question is how do we go about selecting a material for a given part? This may seem like a very complicated process until we realize than we are often restrained by choices we have already made. For example, if different parts have to interact then material choice becomes limited.

When we talk about choosing materials for a component, we take into account many different factors. These factors can be broken down into the following areas.

- **Material Properties**
  - The expected level of performance from the material
- **Material Cost and Availability**
  - Material must be priced appropriately (not cheap but right)
  - Material must be available (better to have multiple sources)
- **Processing**
  - Must consider how to make the part, for example:
  - Casting
  - Machining
  - Welding

- **Environment**
  - The effect that the service environment has on the part
  - The effect the part has on the environment
  - The effect that processing has on the environment

Now clearly these issues are inter-linked in some fashion. For example, cost is a direct result of how difficult a material is to obtain and to machine. And the effect of the environment on the material is clearly related to the material properties.

So if we really want to use a novel or unusual material, the choice must be made early in the design process. Then we can do the detailed design work using the correct material properties.

Consider the example of wooden airplanes and metal-framed airplanes. If we were to design an airplane of either material, we will have to make the choice early. The end designs are quite different. So, the material choice can radically alter the final design. But the possibility also exists that it may not. After all what is the real difference between a 1045 and a 1035 carbon steel?

❖ Kinds of Materials (What kind of materials can I use? Can we use:

- Metals
  - Iron
  - Aluminum
  - Copper
  - Magnesium
- Non-metals

  Composites
- Ceramics
  - Glass
  - Semi-conductors
  - Structural ceramics (Sin, Sic)
  - Refractory Composites
- Polymers

    - Rubber
    - Plastics
- Liquids
- Gases

As mechanical engineers we deal mostly with metals. Metal properties tend to be well understood and metals are somewhat forgiving materials. We can make small mistakes (sometimes big ones) and get away with a poor design as a result of metal's forgiving nature. We see ceramics and composites all around us, but they tend to be used in special applications because of fabrication costs. This however, is changing. Plastics are among the most common modern material choices. In large volume production, plastics are inexpensive. In small volume productions, plastics can be an extremely expensive choice due to high tooling costs.

Material Properties

As mechanical engineers we are most concerned with characteristics such as:

- Mechanical Properties
    - Strength

      Yield Strength

      Ultimate Tensile Strength

      Shear Strength
    - Ductility
    - Young's Modulus
    - Poisson's ratio

    Hardness
    - Creep High or low temperature behavior
    - Anisotropy
    - Fatigue strength
    - Fracture Toughness
- Physical properties
    - Thermal Properties

Thermal expansion coefficient Thermal conductivity

Specific heat capacity

- Magnetic Properties

- Fabrication Properties

    Ease of machining

    Ease of welding, casting, etc.

    Hardening ability

    Formability

    Availability

    Joining techniques

- Chemical properties

    Environmental Properties

    Corrosion properties

    Toxic effects

    Out-gassing properties

- Gas and Liquids

    Viscosity

However, numerical properties to represent these properties are not easy to find. We would like all this information at our fingers, but it takes some digging. In some cases, objective data does not exist. There is no single, standard place to go and look for all this information. We can however make some recommendations.

You can get good information on particular materials from Standards handbooks, such as the ASM's Books on Metals. You can obtain information on gases and liquids from CRC's Handbooks. And the best place to get information on plastics and composites is from the manufacturer. Web sites are also beginning to offer good information. Check the websites on the course web page for material property information and help in the selection process.

The choice of a material is frequently the result of several compromises. For example, the technical appraisal of an alloy will generally be a compromise between corrosion resistance and several other properties such as strength and weld-ability. And the final selection may come down to a compromise between technical and economic factors. In identifying a material, approach the task in three stages:

- List the material requirements for the design. Use the list of characteristics given above to help you in defining ALL the critical requirements. Rank the requirements in importance to the design's success.
- Select and evaluate candidate materials. By researching the various handbooks and resources, attempt to rank your candidate materials as to how well they meet the requirements. Use a decision table to identify the best choices.
- Choose the most economical material. Research material costs according to their availability (local or imported) and production costs (machining cost, welding cost, forming cost etc.) based upon your anticipated production run. Choose the least expensive of your best choice candidate materials.

We would like to know how to rank and select materials. Consider the airplane problem mentioned earlier. In that case we would like a material that is stiff yet light. What could we do to help arrive at an appropriate material choice? How could we create some numerical standing that would help us compare one material with another?

The following procedure is taken from Material Selection in Mechanical Design by Michael Ashby.

- **Four Basic Steps**

  1. Translation: express design requirements as constraints and objectives

  2. Screening: eliminate materials that cannot do the job

  3Ranking: find materials that best do the job

  4. Supporting Info: handbooks, expert systems, web, etc.

1) **Step 1) Translation**

   - Function: What does the component do?
   - Objective: What essentials conditions must be met?
   - Constraints: What is to be maximized or minimized?

- Free Variables: Identify which design variables are free?

Example: Tie Rod

Function: Support a tensile load

Objective: Minimize mass

Constraints: Required length

Load carrying capability w/o/ failure

Free Variables: Cross-sectional area

Material

m = A*L*Density

F/A < Yield Stress

Eliminate free variable

m >= (F)(L) (Density/Yield Stress)

Therefore, minimize weight by maximizing

Yield Stress / Density

Step 2) Screening

Methods to evaluate large range of materials

Material Bar Charts

Material Property Charts(density vs. Young's Modulus)

Screen on Constraints

Rank on Objectives

Step 3) Ranking

What if multiple materials remain after screening?

Rank on Objectives define performance metrics

Objectives define performance metrics

Step 4) Se handbooks, expert systems, web, etc.

Then verify with any supporting material

Self-Check -1	Choose test

Direction-Choose the best answer

1. Selecting materials for manufacturing engineering applications
   - A. Selecting a material
   - B. Specifying a shape
   - C .Choosing a manufacturing
   - D .All
2. .Choosing a manufacturing *Low-Carbon Steels*
   - A railway wheels
   - B. automobile bodies
   - C. chisels, hammers
   - D.None
3: cutting tools can be made by____________
   - *A. Low-Carbon Steels*
   - B. Medium-Carbon Steels
   - C. High-Carbon Steels
   - D.None

Note: **Satisfactory rating –7points** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: ______________

Name: ___________________________ Date: ________________

Short Answer Questions

Information sheet 2	Identifying materials for testing

1. 1 Identifying Material for Testing

Testing of materials is necessary for many reasons, and the subject of materials testing is very broad one. Some of the purposes for the testing of materials are:

- To determine the quality of a material. This may be one aspect of process control in production plant.
- To determine such properties as strength, hardness, and ductility.
- To check for flaws within a material or in a finished component.
- To assess the likely performance of the material in a particular service condition.

It is obvious that there is not one type of test that will provide all the necessary information about a material and its performance capabilities, and there are very many different types of test that have been devices for use in the assessment of materials. One of the most widely tests is the tensile test to destruction. In this type of test a test-piece of standard dimensions is prepared, and this is then stressed in an axial tension. Other tests that are often used for the determination of strength data are compression, torsion, hardness, creep and fatigue tests. With the exception of harness tests, these are all test of a destructive nature and they normally require the preparation of test-pieces to certain standard dimensions.

For the detection of flaws or defects within part-processed stock material, or within finished components, there are several non-destructive test techniques available. In addition, there are many special tests that have been devised for the purpose of assessing some particular quality of material, or for obtaining information on the possible behavior of component or assembly in service.

In spite of the properties of materials where introduced, then the composition, processing and heat treatment of a range of metallic adnoun-metallic materials widely used by the engineer have been described, we should more be able to understand the problems and techniques associated with the testing of materials properties because they can be, nonetheless, useful to the designer, fabricator, and research worker, as follow:

TESTING OF METALS

Metal testing is accomplished for the purpose of for estimating the behavior of metal under loading (tensile, compressive, shear, torsion and impact, cyclic loading etc.) of metal and for providing necessary data for the product designers, equipment designers, tool and die designers and system designers. The material behavior data under loading is used by designers for design calculations and determining whether a metal can meet the desired functional requirements of the designed product or part. Also, it is very important that the material shall be tested so that their mechanical properties especially their strength can be assessed and compared. Therefore the test procedure for developing standard specification of materials has to be evolved. This necessitates both destructive and non-destructive testing of materials.

Destructive tests of metal include various mechanical tests such as tensile, compressive, hardness, impact, fatigue and creep testing. A standard test specimen for tensile test is shown in Fig. 14 Non-destructive testing includes visual examination, radiographic tests, ultrasound test, liquid penetrating test and magnetic particle testing.

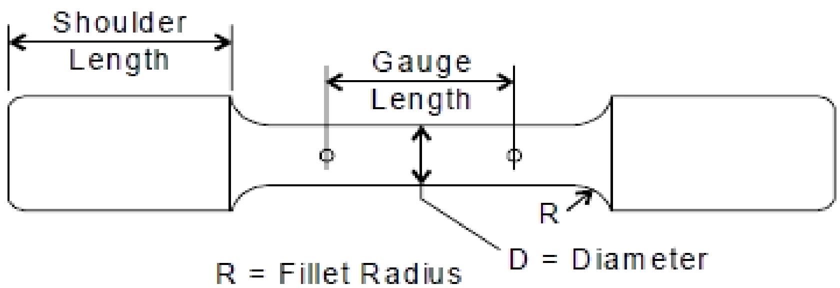


Figure 14 materials for tensile test

- **Tensile test**

The main principle of the tensile test is denotes the resistance of a material to a tensile load applied axially to a specimen. There are several tensile testing machines, as in figure 15(a) shows popular bench-mounted tensile testing machine, whilst figure 15(b) shows a more sophisticated machine suitable for industrial and research laboratories, while in figure 15(c) shows the schematic drawing of a tensile testing apparatus. These machines are capable of performing compression, shear and bending tests as well as tensile test

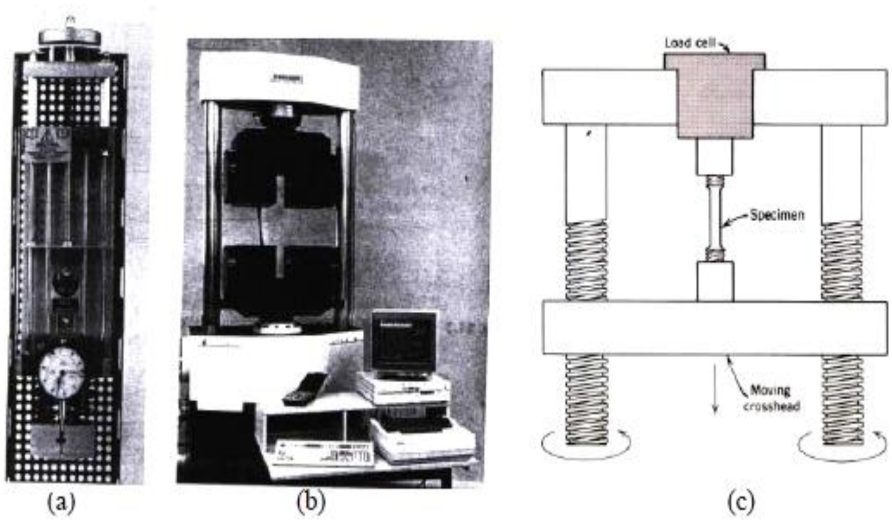
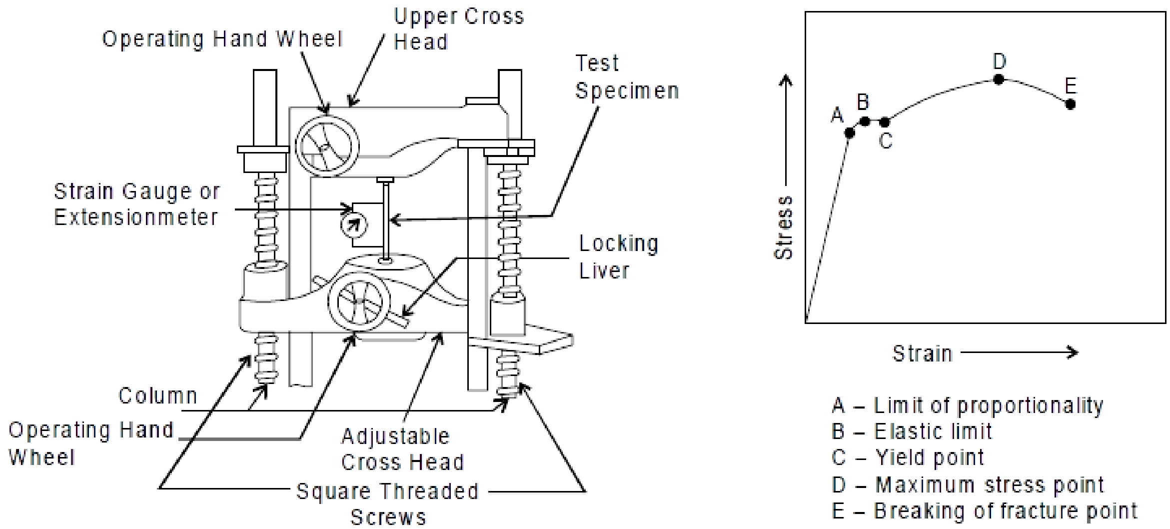


Figure 15 Tensile testing machines

A tensile test is carried out on standard tensile test specimen in universal testing machine. Fig. 16A shows a schematic set up of universal testing machine reflecting the test specimen griped between two cross heads. Fig. 16B shows the stress strain curve for ductile material. Fig. 17 shows the properties of a ductile material. Fig. 18 A) shows the stress strain curves for wrought iron and steels. Fig. 18 B) shows the stress strain curve for non ferrous material.



(A) (B)

Figure 16 Universal Tensile testing machine

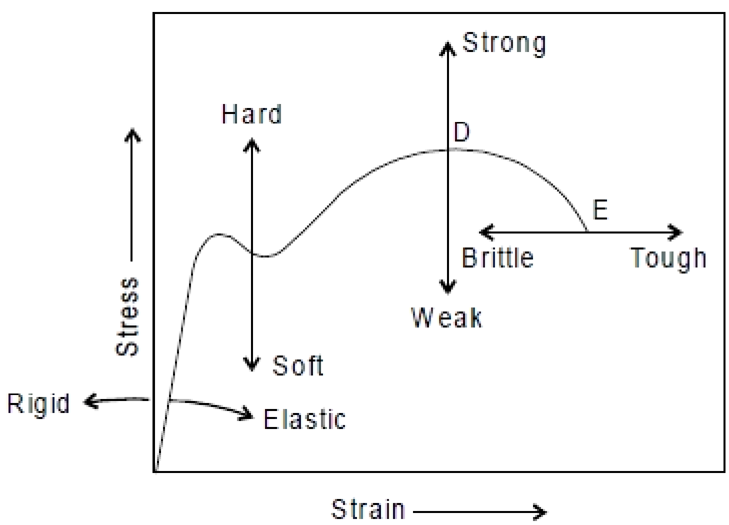


Figure 17 Properties of Ductile materials

It is very important to the tensile test to be considered is the standard dimensions and profiles are adhered to. The typical progress of tensile test can be seen in figure 19.

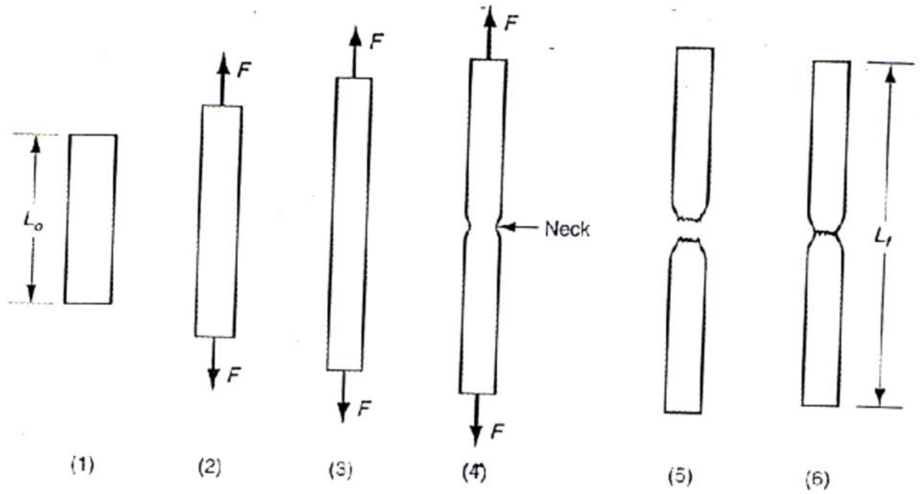


Figure 19 Typical progress of a tensile test: (1) beginning of test, no load; (2)uniform elongation and reduction of cross-sectional area; (3) continued elongation, maximum load reached; (4) necking begins, load begins to decrease; and (5)fracture. If pieces are put back together as in (6), final length can be measured.

Let's now look at Figure 20 In this figure, the *gauge length* (L_0) is the length over which the elongation of the specimen is measured. The *minimum parallel length* (L_c) is the minimum length over which the specimen must maintain a constant cross-sectional area before the test loads applied. The lengths L_o, L_c, L_i. and the cross-sectional area *(A)* are all specified in BS 18.

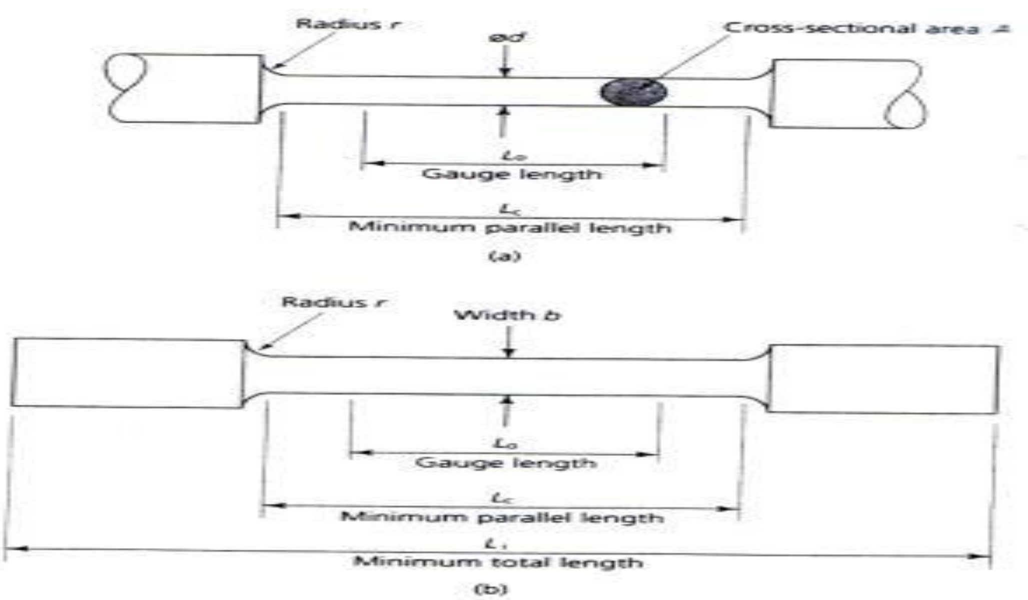


Figure 20 Properties of tensile test specimens: (a) cylindrical; (b) flat

The elongation obtained for a given force depends upon the length and area of the cross-section of the specimen or component, since:

$$\delta = \frac{P \times L}{A \times E}$$

Where L = length
A = cross-sectional area
E = elastic modulus

Therefore, if the ratio [L/A] is kept constant (as it is in a proportional test piece), and *E* remains constant for a given material, then comparisons can be made between elongation and applied force for specimens of different sizes.

Let's now look at the sort of results we would get from a typical tensile test on a piece of annealed low-carbon steel. The load applied to the specimen and the corresponding extension can be plotted in the form of a graph, as shown in Figure 21.

- **Compression Test**

Compression test is reverse of tensile test. This test can also be performed on a universal testing machine. In case of compression test, the specimen is placed bottom crossheads. After that, compressive load is applied on to the test specimen. This test is generally performed for testing brittle material such as cast iron and ceramics etc. Fig. 22 shows the schematic compression test set up on a universal testing machine. The following terms have been deduced using figures pertaining to tensile and compressive tests of standard test specimen.

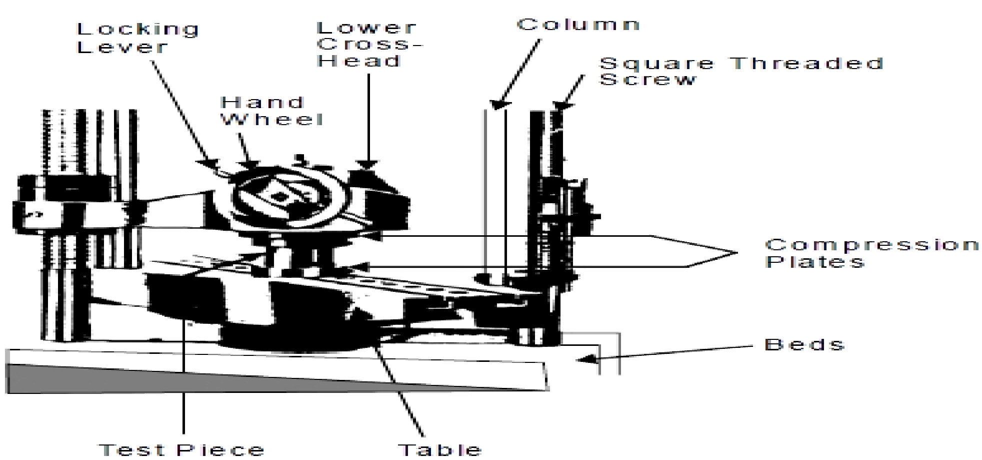


Figure 22 Schematic compression test set up on a universal testing machine

Self-Check -2	Written Test

Direction-Choose the best answer

1. This test is generally performed for testing brittle material such as cast iron

A. tensile test
B. Compression Test
C. Hardness test
D.none

2. The resistance of a material to a load applied axially to a specimen.

A. Hardness test
B. Compression Test
C. tensile test
D.None

3. Accomplished for the purpose of for estimating the behavior of metal under loading (tensile, compressive, shear, torsion and impact)

A. Hardness test
B Testing metals
C. Ductile cast iron
D.None

4. Some of the purposes for the testing of materials are:

A. To determine the quality of a material
B To determine such properties as strength, hardness, and ductility
C. To check for flaws within a material or in a finished component
D. All is the answerers

Note: **Satisfactory rating –7points** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________

Rating: ____________

Name: ___________________________ Date: ________________

Short Answer Questions

Information Sheet 3	**Identifying materials for** destructive **testing**

1 Destructive Testing:

Destructive testing is changes the dimensions or physical and structural integrity of the specimen. (It is essentially destroyed during the test

- Tension
- Compression
- Hardness
- Fatigue
- Creep
- Torsion

2. **Nondestructive testing:**

Non-Destructive testing does not affect the structural integrity of the sample

- Visual inspection
- Eddy current
- Magnetic
- Ultrasonic
- Visual inspection

Mechanical Testing

Ultimate Tensile Strength - The maximum tensile stress that a material is capable of developing during a test.

Load- Applied force either pounds or newtons

Stress - The intensity of the internally-distributed forces or components of forces that resist a change in the form of a body. Commonly measured in units dealing with force per unit area, such as pounds per square inch (PSI or lb/in^2) or Megapascals (Mpa). The three basic types of stress are tension, compression, and shear. The first two, tension and compression, are called direct stresses.

Elastic Limit - The greatest amount of stress a material can develop without taking a permanent set.

Percent Elongation - The total percent strain that a specimen develops during testing.

The engineering stress is:

Stress

$$Stress = \frac{Force\ (or\ load)}{Area} \qquad \sigma = \frac{F}{A}$$

The engineering strain is:

Strain

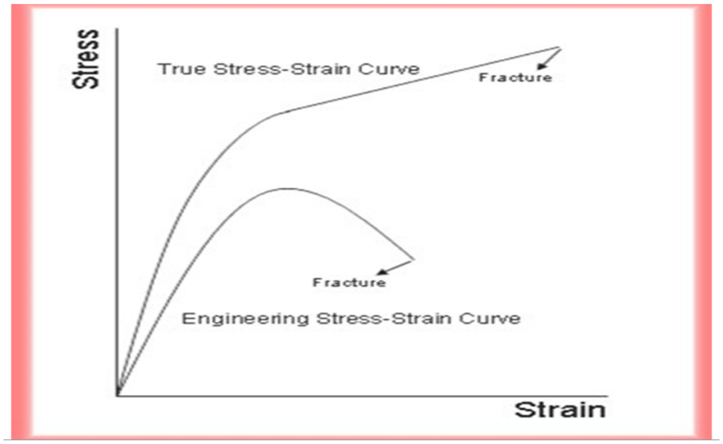
$$Strain = \frac{Length\ of\ Stretch}{Original\ Length} \qquad \varepsilon = \frac{\delta}{L}$$

Principal properties determined through tensile testing include yield strength, tensile strength, ductility (based on the percent elongation and percent reduction in area), modulus of elasticity, and visual characteristics of the fracture. For brittle materials, which do not show a marked yield or ductility, data is collected for tensile strength and type and condition of fracture.

Expected Results

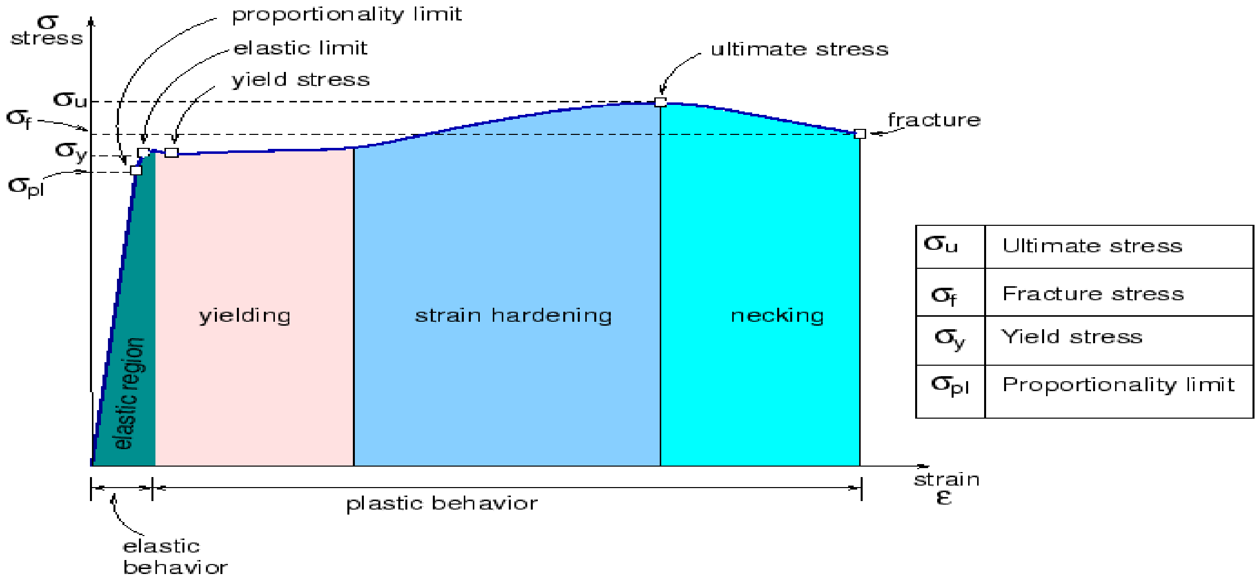
The results of tensile testing can be used to plot a stress-strain curve which illustrates the tensile properties of the material. Stress (in pounds per square inch or Pascal's) is plotted on the vertical axis while strain (inches per inch, millimeters per millimeter, or unit less) is plotted along the horizontal.

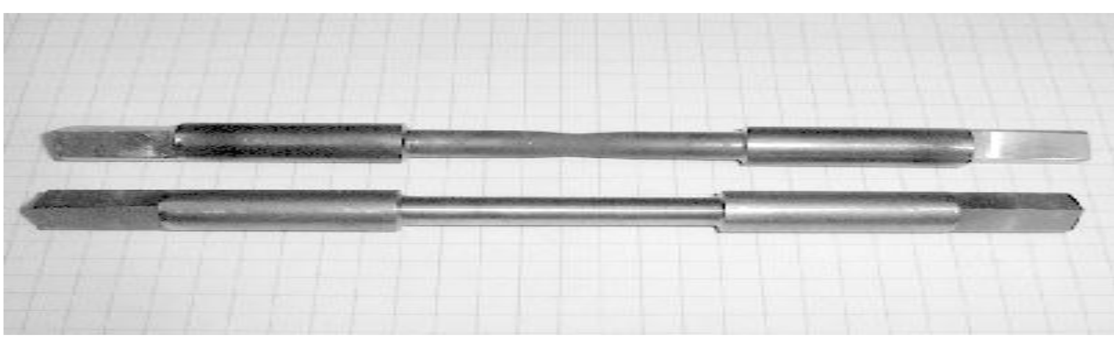
As the load is applied, the curve is proportional and this period of linearity is termed the elastic region. Once the curve deviates from a straight line and begins to yield, the material has reached the proportional limit. Once the material has yielded, it exhibits plastic behavior or plasticity. Brittle materials do not exhibit much yield and are, therefore, less curved than ductile materials.

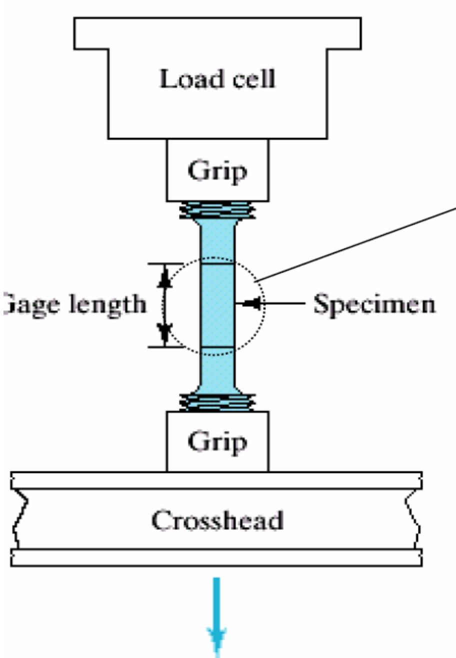


Stress-Strain Curve

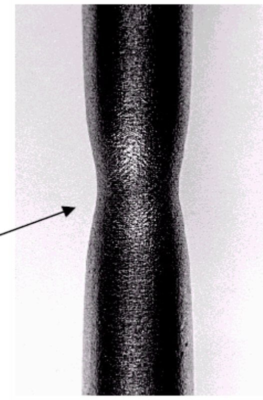
This stress-strain curve is produced from the tensile test.

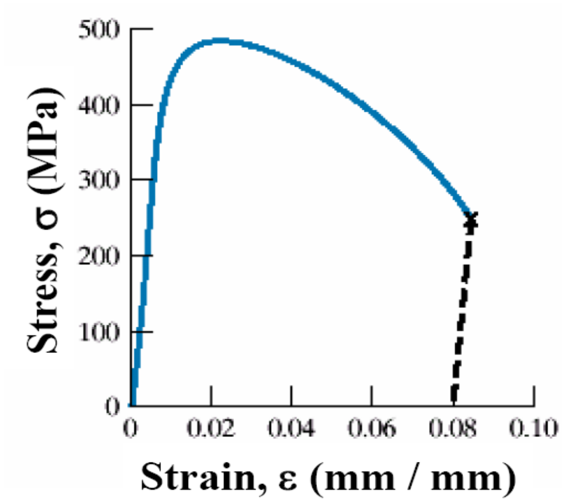




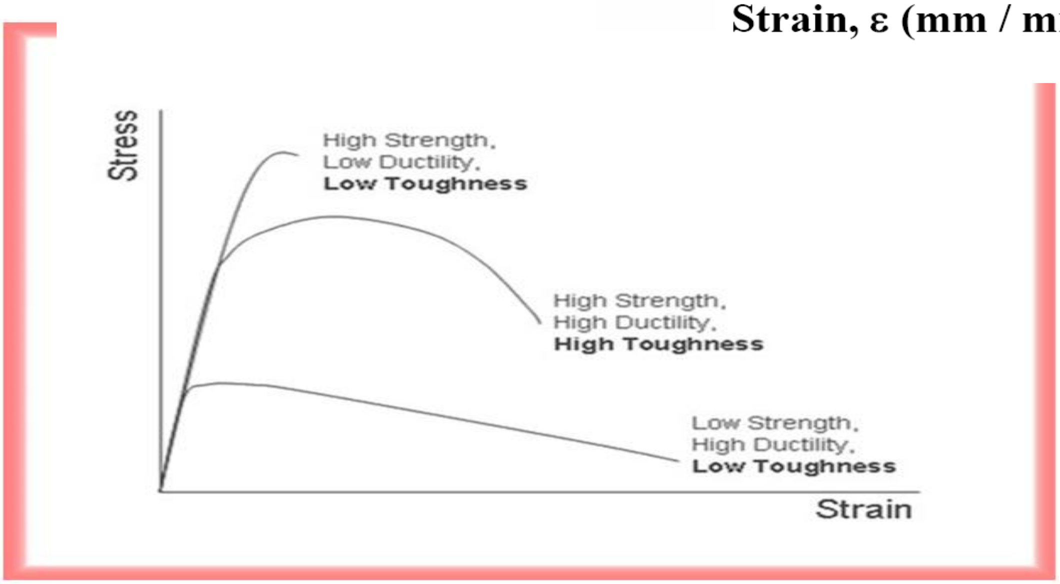


Load cell
Grip
Gage length
Specimen
Grip
Crosshead





Stress, σ (MPa)
500
400
300
200
100
0
0
0.02
0.04
0.06
0.08
0.10
Strain, ε (mm / mm)



Stress
High Strength,
Low Ductility,
Low Toughness
High Strength,
High Ductility,
High Toughness
Low Strength,
High Ductility,
Low Toughness
Strain

To compare specimens of different sizes, the load is calculated per unit area.

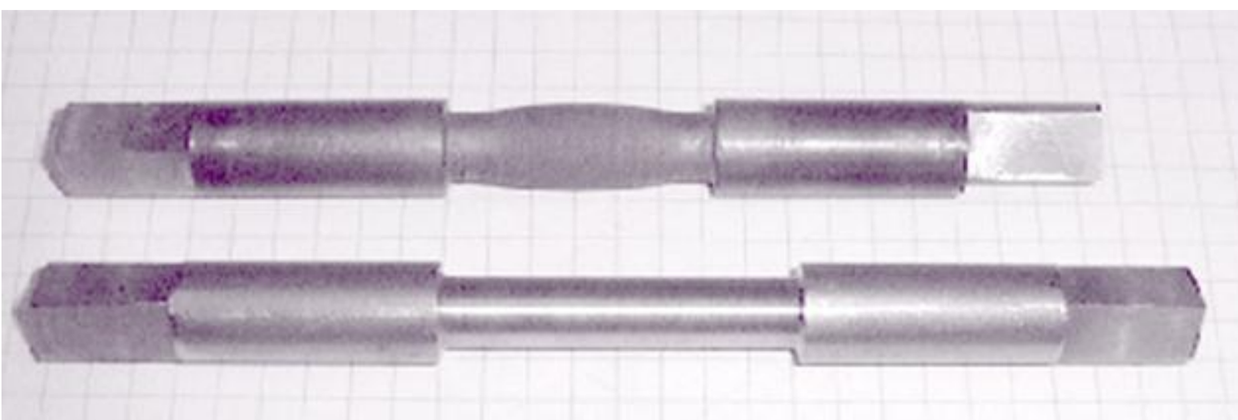
Engineering stress: $\sigma = F / A_o$

F is load applied perpendicular to speciment cross-section; A_0 is cross-sectional area (perpendicular to the force) **before** application of the load.

Engineering strain: $\varepsilon = \Delta l / l_o \quad (\times 100\ \%)$

Δl is change in length, l_o is the original length.

These definitions of stress and strain allow one to compare test results for specimens of different cross-sectional area A_0 and of different length l_0.



•Tensile tests are used to determine the tensile properties of a material, including the tensile strength. The tensile strength of a material is the maximum tensile stress that can be developed in the material.

•In order to conduct a tensile test, the proper specimen must be obtained. This specimen should conform to ASTM standards for size and features. Prior to the test, the cross-sectional area may be calculated and a pre-determined gage length marked.

•The specimen is then loaded into a machine set up for tensile loads and placed in the proper grippers. Once loaded, the machine can then be used to apply a steady, continuous tensile load.

•Data is collected at pre-determined points or increments during the test. Depending on the material and specimen being tested, data points may be more or less frequent. Data include the applied load and change in gage length. The load is generally read from the machine panel in pounds or kilograms.

•The change in gage length is determined using an extensometer. An extensometer is firmly fixed to the machine or specimen and relates the amount of deformation or deflection over the gage length during a test.

•While paying close attention to the readings, data points are collected until the material starts to yield significantly. This can be seen when deformation continues without having to increase the applied load. Once this begins, the extensometer is removed and loading continued until failure. Ultimate tensile strength and rupture strength can be calculated from this latter loading.

•Once data have been collected, the tensile stress developed and the resultant strain can be calculated. Stress is calculated based on the applied load and cross-sectional area. Strain is the change in length divided by the original length.

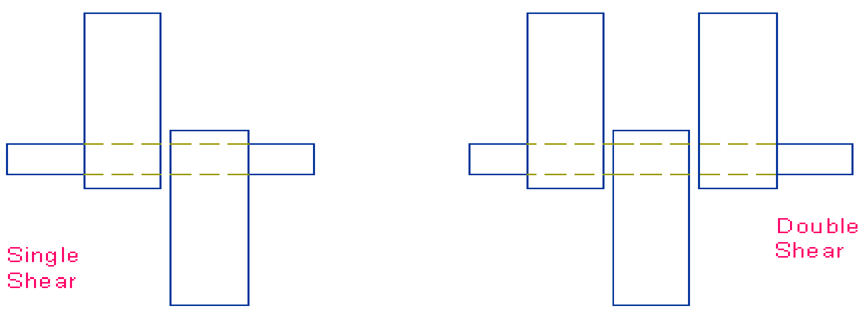
Shear Testing - Introduction

•Shear testing involves an applied force or load that acts in a direction parallel to the plane in which the load is applied. Shear loads act differently than, say, tensile or compressive loads that act normal or perpendicular to the axis of loading. Direct shear and torsional shear are important forces used to determine shear properties. Direct or torsional loading depends on the forces a material is expected to be subjected to during service.

Shear Testing - Procedure

•Before testing, the specimen is accurately measured using proper instruments and the gage length is marked. The troptometer or a suitable replacement is attached to the specimen and zeroed out. Proper precautions should be taken to center the specimen in the machine or fixture. The grippers are tightened to insure against slippage, yet not so tight as to cause deformations which would affect test results.

•In general, shear testing involves either direct or torsional loading. In direct shear tests, the specimen is placed in the shear test fixture and a load is applied. This can be seen in the figure below. For plate specimens, a punch and die combination may be used. Plastics, generally, are square specimens with holes in either end to facilitate gripping. The applied load and resultant deformation are recorded and a suitable graph can be plotted.

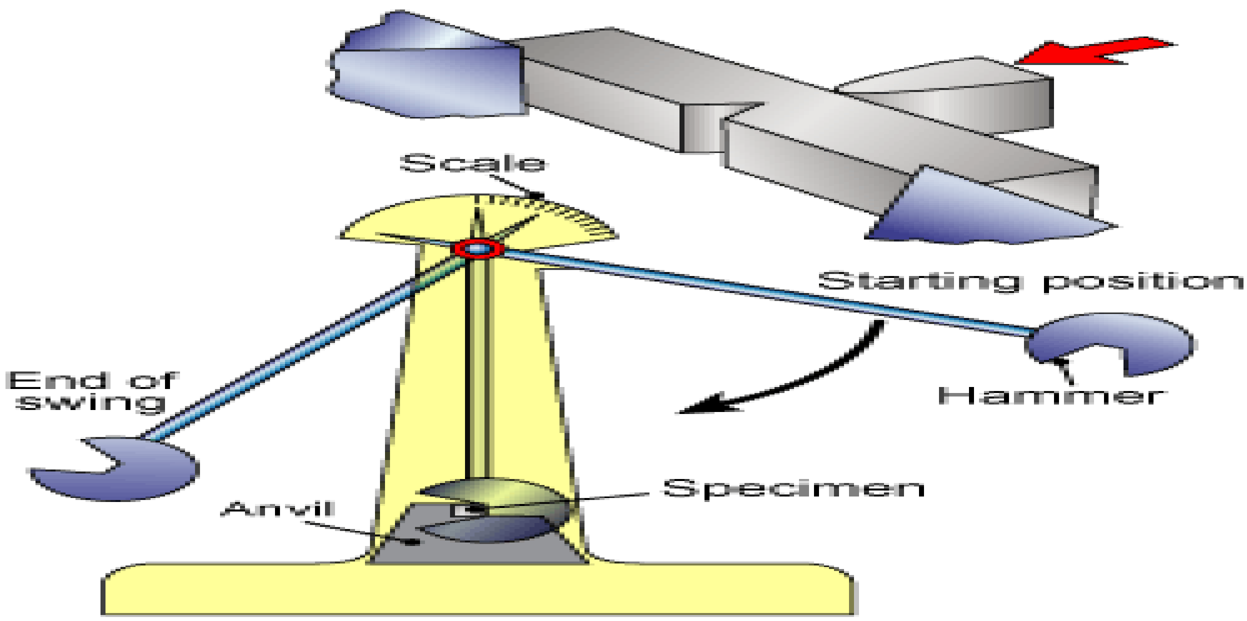


Transverse Shear Test Fixture

Impact Testing – Introduction

•A specimen under test will exhibit different properties, depending on the rate at which the load is applied. For example, most materials will exhibit greater strength is the load is applied in a slower, gentler manner (static loading) than suddenly (dynamic). Because properties are strain-rate dependent, tests have been standardized to determine the energy required to break materials used sudden blows. These are termed impact tests.

•Impact tests generally involve sudden shock loading that results in breakage of the specimen. The result is calculated based on the energy required to break the specimen and the resultant loss of momentum. This can be calculated if one knows the initial energy and final energy or the initial angle and final angle of the object used to break the specimen. The Izod and Charpy tests are commonly used to measure impact strength. They differ only slightly, the configuration and specifications of the test specimen.



Hardness Testing - Introduction

•Hardness, as a mechanical property, is the resistance of a material to surface penetration. Therefore, most hardness tests involve measuring the amount of force required to implant a specified indentation in the surface of a specimen OR the size of the indentation produced from applying a specified load. The indenter used varies with the test selected, but is generally hardened steel or diamond.

•Other types of hardness tests involve the rebound of a dynamic or impact load, such as the scleroscope. The amount of rebound that results is used as an indication of the surface hardness of the specimen.

•Common hardness tests include the Rockwell and Brinell. Other test procedures used include the scleroscope, surface abrasion testing, Vickers, and Tukon-Knoop.

Rockwell Hardness Test

•The Rockwell hardness test relies on a specified load and the size of the indentation or penetration made to determine the hardness value. Rockwell hardness tests involve selecting the magnitude of the load to apply based on the suspected hardness of the specimen. Rockwell tests, however, use a variety of indenters, depending on the material and suspected hardness.

•The Rockwell hardness test provides more direct results. A specially-designed testing machine is typically used and provides a dial reading for the Rockwell Hardness Number, so no special calculations or measurements are necessary.
In the Rockwell hardness test, the specimen is loaded on a platen and raised with an elevating screw to contact the indenter, the indenter having been selected for the material and hardness being scrutinized and previously installed in the testing machine.

•The indenter may be a 1/16 inch hardened steel ball, a 1/8 inch hardened steel ball, or a 120° diamond cone ground to a point, called a brale. Once the specimen is loaded, the platen is raised to contact the indenter to a specified set point on the machine's readout. This point is used to indicate that the minor load has been applied. By raising the platen and specimen against the indenter, a small, minor load drove the indenter into the specimen to initially set the indenter into the specimen. The minor load is typically 10 kg.

•The major load may now be released to drive the indenter further into the specimen. Major loads typically range from 60-100 kg when the steel ball is used and 150 kg when the brale is used. Once the major load has been released, sufficient time is allowed for the dial to come to rest, generally between 30 and 60 seconds, depending on the material.

•The major load is then removed and the Rockwell Hardness Number read directly from the readout on the machine with the minor load remaining. This provides a value based on the distance the indenter was driven into the specimen by the major load. Once the reading is taken, the elevating screw is used to release the minor load and the specimen may be removed.

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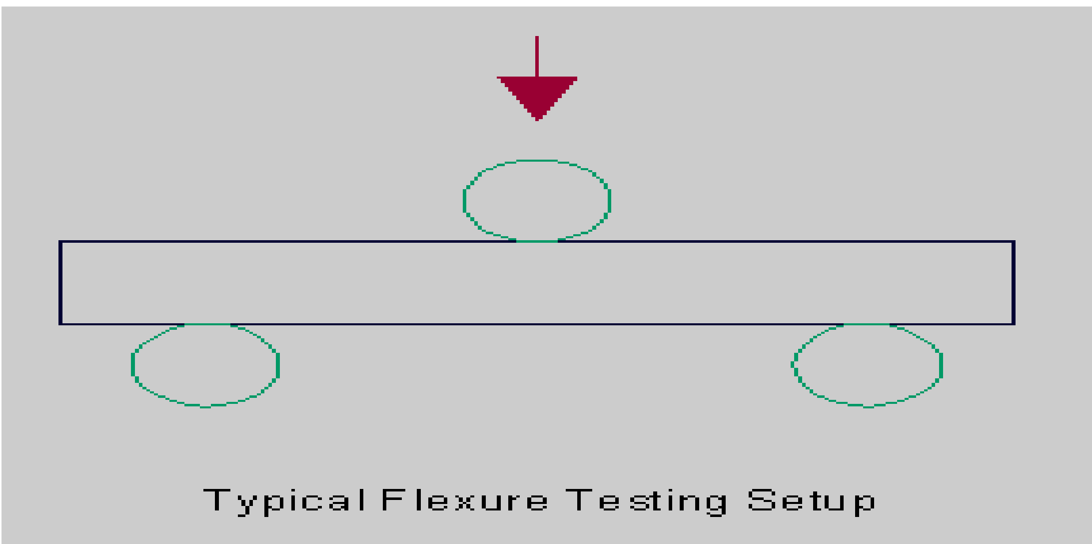
Flexure Testing - Introduction

Forces that tend to induce compressive stresses over one part of a cross-section and tensile stresses over the remainder are described as bending or flexural forces. Bending can be accompanied by direct stresses, transverse shear, or torsional shear, depending on loading. Bending action in beams is often termed flexure, referring to transverse loading of the beam. The deflection of the specimen is the displacement of a point on the neutral axis of the beam from its original position under the action of the applied loads. The figure, the deflection, is an indication of the overall stiffness of the material.

Flexure or Bend Testing - Procedure

In flexure or bend testing, the specimen is typically loaded flat on two solid support rods. A third rod is used for loading. This setup helps insure three-point loading which allows the tensile forces to act from the center loading point outward toward the two support rods. Once the specimen has been accurately measured using proper instruments and the machine properly set up, loading continues in a slow, steady manner. The flexure strength and modulus of rupture may be calculated based on these data. A load-versus-deflection curve or stress-strain curve can be plotted based on the data.



Self-Check -3	Choose test

Direction-Choose the best answer

1. Does not affect the structural integrity of the sample
   A. Non-Destructive testing C.Destructive testing
   B. Material testing D. Pyrite
2. Which one is destructive testing is changes the dimensions or physical change..
   A. Visual inspection C. Magnetic
   B. Eddy current D. Torsion

3. Test determines the hardness by measuring the depth of penetration of an indenter
   A .Vickers hardness test C. Tensile testing
   B.The Rockwell scale D. None

4. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure'
   A. Vickers hardness test C. Tensile specimen
   B. the Rockwell scale D .None

Note: Satisfactory rating –7points Unsatisfactory - below 7 points

You can ask you teacher for the copy of the correct answers.

Answer Sheet

Score = ____________
Rating:

Name: ___________________________ Date: ________________

Short Answer Question

Information Sheet-4	Preparing materials and equipment based on Standardized test.

Hardness testing

It is a very important property of the metals and has a wide variety of meanings. It embraces

Many different properties such as resistance to wear, scratching, deformation and mach inability

Etc. It also means the ability of a metal to cut another metal.

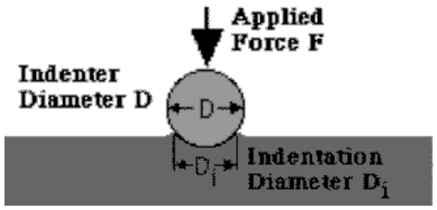
The hardness of a metal may be determined by the following tests:

- Brinell hardness test,
- Rockwell hardness test
- Vickers hardness (also called Diamond Pyramid) test, and
- Shore scleroscope

The Brinell hardness Test

The Brinell hardness test method consists of indenting the test material with a tungsten carbide ball of either 1, 2.5, 5 or 10 mm diameter by applying a test force of between 1 and 3000 kgf. The full load is normally applied for 10 to 15 seconds in the case of iron and steel and for at least 30 seconds in the case of other metals. The diameter of the indentation left in the test material is measured. The Brinell harness number is calculated by dividing the load applied by the surface area of the indentation.

The diameter of the impression is the average of two readings at right angles and the use of a Brinell hardness number table can simplify the determination of the Brinell hardness. Modern electronic testers offer inbuilt measuring systems with either manual or computer assisted automatic indentation measurement.



$$BHN = \frac{F}{\frac{\pi}{2} D \cdot (D - \sqrt{D^2 - D_i^2})}$$

A well-structured Brinell hardness number reveals the test conditions, for example "75 HBW 10/500/30" which means that a Brinell Hardness of 75 was obtained using a 10mm diameter tungsten carbide ball with a 500 kgf test force for a period of 30 seconds. When testing extremely hard metals the tungsten
carbide ball indenter may not be suitable as the Brinell scale is limited to materials with hardness values of approximately 650 HBW. For such materials the Rockwell and Vickers tests are more suitable.
Compared to the other hardness test methods, the Brinell ball makes the deepest and widest indentation, so the test averages the hardness over a wider amount of material, which will more accurately account for multiple grain structures and any irregularities in the uniformity of the material. This method is the best for achieving the bulk or macro-hardness of a material, particularly those materials with heterogeneous structures.

Vickers hardness test

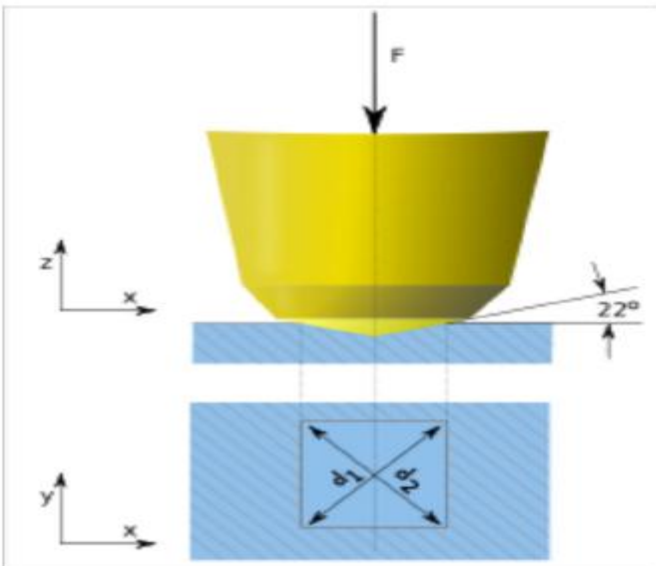
The Vickers hardness test was developed in 1921 by Robert L. Smith and George E. Sand land at Vickers Ltd as an alternative to the Brielle method to measure the hardness of materials. The Vickers test is often easier to use than other hardness tests since the required calculations are independent of the size of the indenter, and the indenter can be used for all materials irrespective of hardness.

The pyramidal diamond indenter of a Vickers hardness tester.

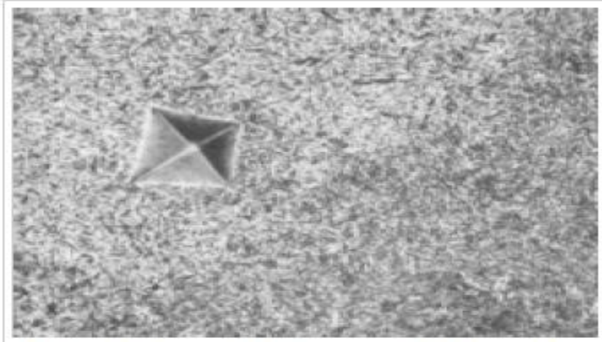
The basic principle, as with all common measures of hardness, is to observe the questioned material's ability to resist plastic deformation from a standard source. The Vickers test can be used for all metals and has one of the widest scales among hardness tests. The unit of hardness given by the test is known as the Vickers Pyramid Number (HV) or Diamond Pyramid Hardness
(DPH). The hardness number can be converted into units of rascals, but should not be confused with a pressure, which also has units of Pascal's. The hardness number is determined by the load over the surface area of the indentation and not the area normal to the force, and is therefore not a pressure. The hardness number is not really a true property of the material and is an empirical value that should be seen in conjunction with the experimental methods and hardness scale used.

The Rockwell scale

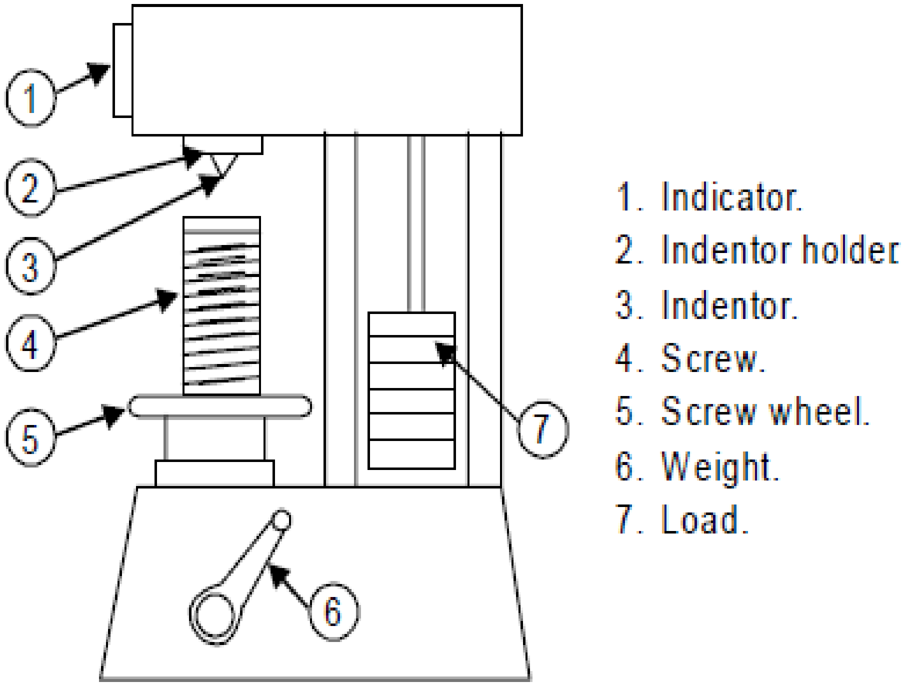
The Rockwell scale is a hardness scale based on the indentation hardness of a



Vickers test scheme


An indentation left in case-hardened steel after a Vickers hardness test. Notice the difference in length of both diagonals and the illumination gradient, which are both classic indications of an out-of-level sample. This is not a good indentation.

material. The Rockwell test determines the hardness by measuring the depth of penetration of an indenter under a large load compared to the penetration made by a preload.[1] There are different scales, denoted by a single letter, that use different loads or indenters. The result is a dimensionless number noted as HRA, where A is the scale letter. When testing metals, indentation hardness correlates linearly with tensile strength. This important relation permits economically important nondestructive testing of bulk metal deliveries with lightweight, even portable equipment, such as hand-held Rockwell hardness testers.



Tensile testing

Tensile testing, also known as tension testing, is a fundamental materials science test in which a sample is subjected to uniaxial tension until failure. The results from the test are commonly used to select a material for an application, for quality control, and to predict how a material will react under other types of forces. Properties that are directly measured via a tensile test are ultimattensile strength, maximum elongation and reduction in area. From these measurements the following properties can also be determined: Young's modulus, Poisson's ratio, yield strength, and strain-hardening.

Structure/Hardness

STRUCTURE	HARDNESS *BHN*	HARDNESS ROCKWELL C	TEMPERATURE OF TRANSFORMATION ℃
Coarse pearlite	170 293	5 31	720 660
Fine pearlite	388	41	580
Feathery bainite (upper)	401 415	42 44	500 400
Acicular bainite (lower)	555 578	56 58	280 230
Bainite & Martensite	601	60	175

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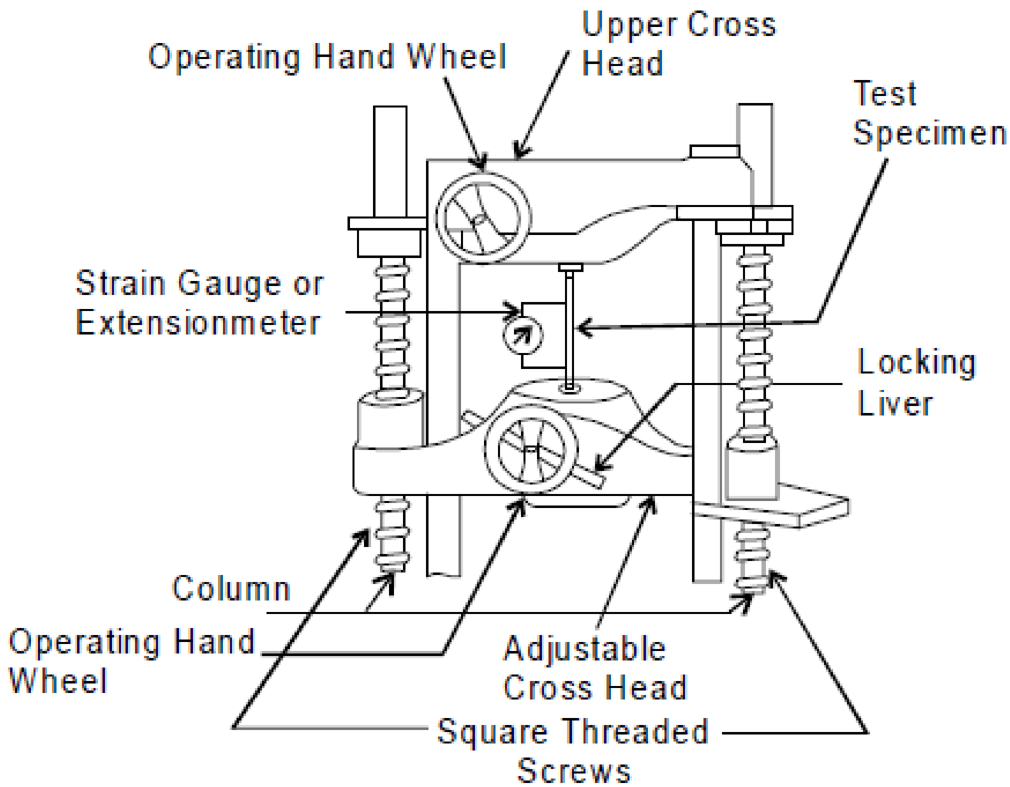


Fig Schematic universal testing Machine

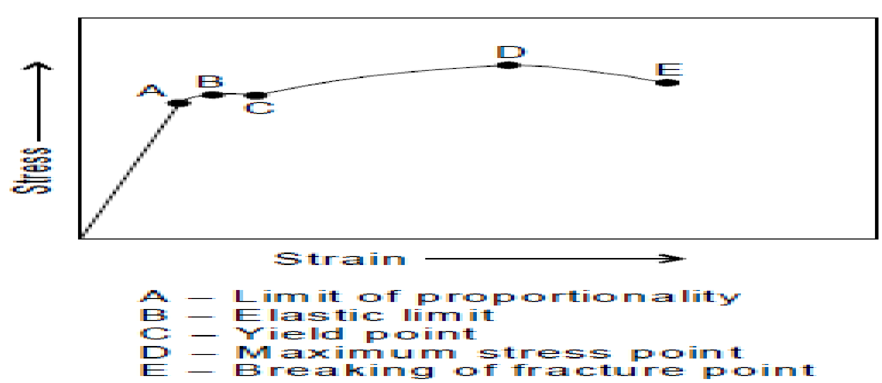
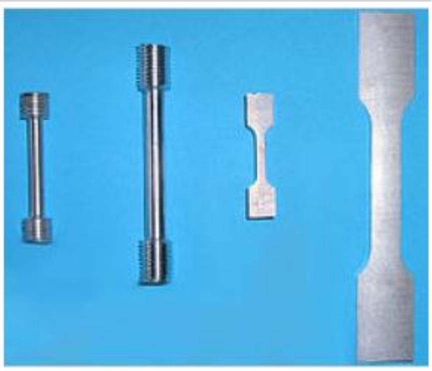


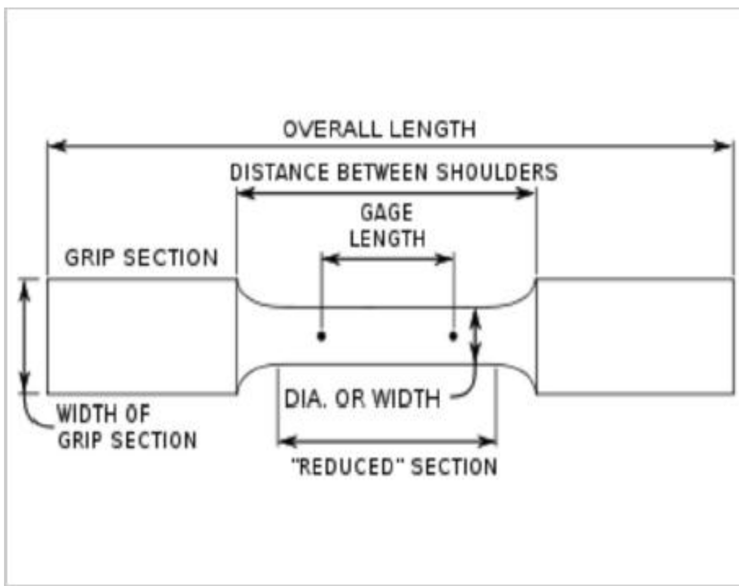
Fig: Stress strain curve for ductile material

Tensile specimen

A tensile specimen is a standardized sample cross-section. It has two shoulders and a gauge (section) in between. The shoulders are large so they can be readily gripped, whereas the gauge section has a smaller cross-section so that the deformation and failure can occur in this area. The shoulders of the test specimen can be manufactured in various ways to mate to various grips in the testing machine (see the image below). Each system has advantages and disadvantages; for example, shoulders designed for serrated grips are easy and cheap to manufacture, but the alignment of the specimen is dependent on the skill of the technician. On the other hand, a pinned grip assures good alignment. Threaded shoulders and grips also assure good alignment, but the technician must know to thread each shoulder into the grip at least one diameter's length, otherwise the threads can strip before the specimen fractures.



Tensile specimens made from an aluminum alloy. The left two specimens have a round cross-section and threaded shoulders. The right two are flat specimen designed to be used with serrated grips.

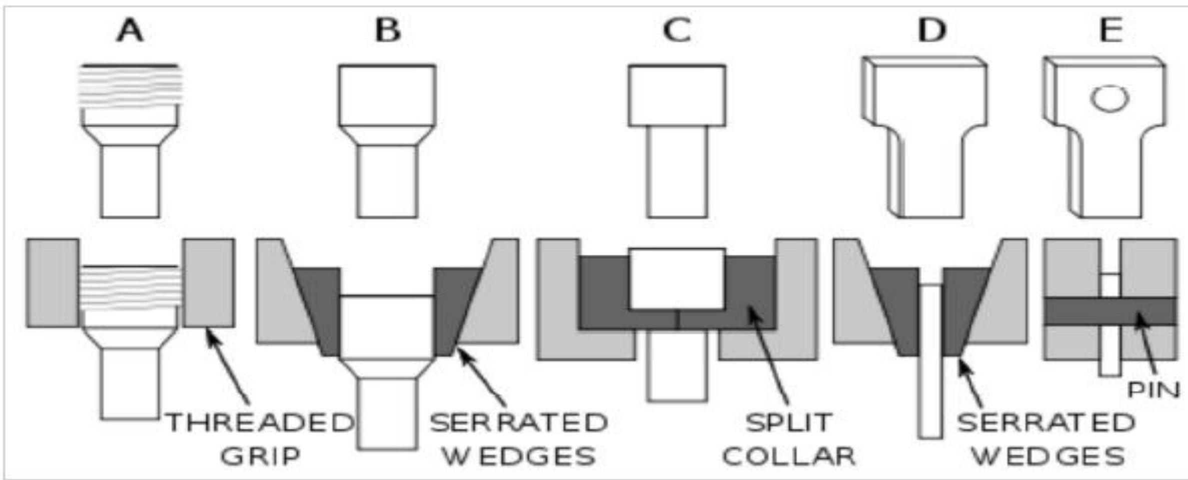


Test specimen nomenclature

Equipment

The most common testing machine used in tensile testing is the universal testing machine. This type of machine has two crossheads; one is adjusted for the length of the specimen and the other is driven to apply tension to the test specimen. There are two types: hydraulic powered and electromagnetically powered machines. The machine must have the proper capabilities for the test specimen being tested. There are three main parameters: force capacity, speed, and precision and accuracy. Force capacity refers to the fact that the machine must be able to generate enough force to fracture the specimen. The machine must be able to apply the force quickly or slowly enough to properly mimic the actual application. Finally, the machine must be able to accurately and precisely measure the gauge length and forces applied; for instance, a large machine that is designed to measure long elongations may not work with a brittle material that experiences short elongations prior to fracturing. Alignment of the test specimen in the testing machine is critical, because if the specimen is misaligned, either at an angle or offset to one side, the machine will exert a bending force on the specimen. This is especially bad for brittle materials, because it will dramatically skew the results. This situation can be minimized by using spherical seats or U-joints between the grips and the test machine. A misalignment is indicated when

running the test if the initial portion of the stress-strain curve is curved and not linear



Various shoulder styles for tensile specimens. Keys A through C are for round specimens, whereas keys D and E are for flat specimens. Key:

A. A threaded shoulder for use with a threaded grip
B. A round shoulder for use with serrated grips
C. A butt end shoulder for use with a split collar
D. A flat shoulder for used with serrated grips

E. A flat shoulder with a through hole for a pinned grip

Self-Check -3	choose Test

Direction-Choose the best answer

1. The machine must have the proper capabilities for the test specimen being tested.
   A. force capacity
   B. speed
   C. precision
   D. all

2. Many different properties such as resistance to wear, scratching, deformation and mach inability
   A. Hardness testing
   B. Tensile testing
   C. Magnetic
   D. None

3. Test determines the hardness by measuring the depth of penetration of an indenter
   A .Vickers hardness test
   B.The Rockwell scale
   C. Tensile testing
   D. None

Note: Satisfactory rating –7points Unsatisfactory - below 7 points

You can ask you teacher for the copy of the correct answers

Answer Sheet

Score = __

Rating:

Name: _________________ Date: _________________

Short Answer Questions

An ask you teacher for the copy of the correct answers.

Operation Sheet 1	Performing tension testing

The purpose of this operation is to give trainees experience in measuring various Strength parameters of different metals materials.

Step 1- wear personal protective equipment PPE

Step 2- to prepare materials to be tested. A36 Hot Rolled Steel blue /black

Step 3- select required Longitudinal round Tensile test (ASTM E8) to be performed on

Step 4- Using a micrometer, measure and record the diameter.

Step 5- . Mark two gage points 2 inches apart on the specimen with a special indenter. Measure the exact distance between the two gage points with a micrometer. Attach a 2-inch extensometer to the specimen at the two gage points.

Step 6- . Place the specimen in the threaded grips and load the specimen slowly to failure. Record the load and deflection for each 300kg load..

Step 7- . Remove the extensometer from the specimen before fracture occurs.

Step 8 - After the specimen has been broken, push the two broken pieces together by hand, and measure the distance between the two gage points by means of a micrometer to determine the total plastic deformation. Measure also the diameter of the reduced cross-section of the fractured specimen

Step 9- Tension test data A36 Hot Rolled Steel Sketch

nitial diameter: ______________________ Diameter at failure: ____________________

Distance between two gage points, initial: ___________ At failure: ____________________

LAP Test	Practical Demonstration

Name: _______________________ Date: _________

Time started: ________________ Time finished: _________

Instructions: You are required to perform the following individually with the presence of your teacher.

Task 1. Perform to wear personal protective equipment PPE

Task 2 Perform to prepare materials to be tested. A36 Hot Rolled Steel blue /black

Task 3. Perform - Using a micrometer, measure and record the diameter.

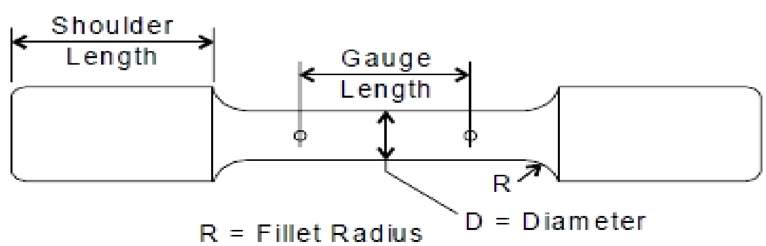
Task 4. Perform. Mark two gage points 2 inches apart on the specimen with a special.

Task 5. Perform. Place the specimen in the threaded grips and load the specimen .

Task 6. Perform After the specimen has been broken, push the two broken pieces.

Task 7. Perform Tension test data A36 Hot Rolled Steel Sketch.

Task 8. Perform using 5s



Load (lbs)	Stress (psi)	Deflection (10^{-3} in.)	Strain (10^{-3})	Load (lbs)	Stress (psi)	Deflection (10^{-3} in.)	Strain (10^{-3})

Mechanics

Level-III

Learning Guide-39

Unit of Competence:	**Determine Welding Materials**
Module Title	**Determining Welding Materials**

Module Code: XXXXX

LG Code: XXXXX

TTLM Code: XXXXX

LO 4: Assure quality results of material test

Instruction Sheet	Learning Guide #39

This learning guide is developed to provide you the necessary information regarding the following content coverage and topics: Recording and reporting materials test results.

- Ensuring appropriate material calibration and traceability.
- Recording and reporting appropriate Materials Safety Data Sheets
- (MSDS) Observation of OHS measures
- Observation of OHS measures

This guide will also assist you to attain the learning outcome stated in the cover page. Specifically, upon completion of this Learning Guide, you will be able to:

- Select materials for use in given mechanical/ manufacturing engineering applications based on relevant test information•
- Classifies identified materials for testing based on relevant test information.
- Prepare materials and equipment are prepared based on to be conducted standardized test

Learning Instructions:

1. Read the specific objectives of this Learning Guide
2. Follow the instructions described below
3. Read the information written in the information “Sheet 1, Sheet 2, Sheet 3 and Sheet 4”
4. Accomplish the “Self-check 1, Self-check t 2, Self-check 3 and Self-check 4” in page -6, 9, 12 and 14 respectively.
5. If you earned a satisfactory evaluation from the “Self-check” proceed to “Operation Sheet 1, Operation Sheet 2 and Operation Sheet 3” in page

This Learning Guide (LG) is geared to providing the students the necessary information regarding the following content coverage and topics:

- Recording and reporting materials test results due to industry practice
- Ensuring appropriate material calibration and traceability. based on regulations
- Recording and reporting appropriate Materials Safety Data Sheets (MSDS)
- Observation of OHS measures throughout the process within the regulations

At the end of this course trainees will gain knowledge about the metallurgic properties of ferrous metals and their uses, Iron ore, production process of iron in blast furnace, the chemical reactions takes place in the production process and classification and grading of Pig iron. Beside this it will give them the basic knowledge about the alloying elements and principles of alloys in ferrous metals.

Learning Activities

- Record materials tests results and reported due to industry practice
- Ensue appropriate material calibration and traceability based on regulations
- Recorded and reported appropriate Materials Safety Data Sheets (MSDS) for applications in accordance with organizational procedures, codes and regulations.
- Observe OHS measures throughout the process within the regulation

Information sheet-1	Recording and reporting materials test results

I. Introduction to recording and reporting materials

1.1 Information and documentation to be submitted the application for approval is to be submitted to the Society by the shop primer Manufacturer or authorized supplier. The following information and supporting documentation, as applicable, are to be submitted:

- type designation, product name
- product description including components of the primer, type of diluents and mixture ratio
- product specification, data sheet giving characteristics of the shop primer and application instruction (surface preparation, method of application, drying time, recommended dry coat thicknesses, etc.) documentation relevant to previous tests and approvals.
- welding procedure specifications used
- Approval test results.

- **Determination of proof strength, total extension *(Rt)***

  The proof strength (total extension) is determined on the force-extension diagram by drawing a line parallel to the ordinate axis (force axis) and at a distance from this equivalent to the prescribed total percentage extension. The point at which this line intersects the curve gives the force corresponding to the desired proof strength. The latter is obtained by dividing this force by the original cross-sectional area of the test piece

  - The property may be obtained without plotting the force-extension diagram by using automatic devices.

- Method of verification of permanent set strength *(Rr)* The test piece is subjected to a force for 10 s to 12 s corresponding to the specified stress and it is then confirmed, after removing the force, that the permanent set extension or elongation is not more than the percentage specified for the original gauge length.

- **Determination of percentage reduction of area (Z)**

Percentage reduction of area shall be determined in accordance with the definition given the two. Broken pieces of the test piece are carefully fitted back together so that their axes lie in a straight line. The minimum cross-sectional area after fracture (Su) shall be measured to an accuracy of ±2 % (see annexes A to D). The diftere.tce between the area (Su) and the original cross-sectional area *(So)* expressed as a percentage of the original area gives the percentage reduction of area.

1.2 Test results accuracy of the results

The accuracy of results is dependent on various parameters which may be separated into two categories

- metrological parameters such as class of machine and extensometer and the accuracy of specimen dimensional measurements;
- Material and testing parameters such as nature of material, test piece geometry and preparation, testing rate, temperature. data acquisition and analysis technique.

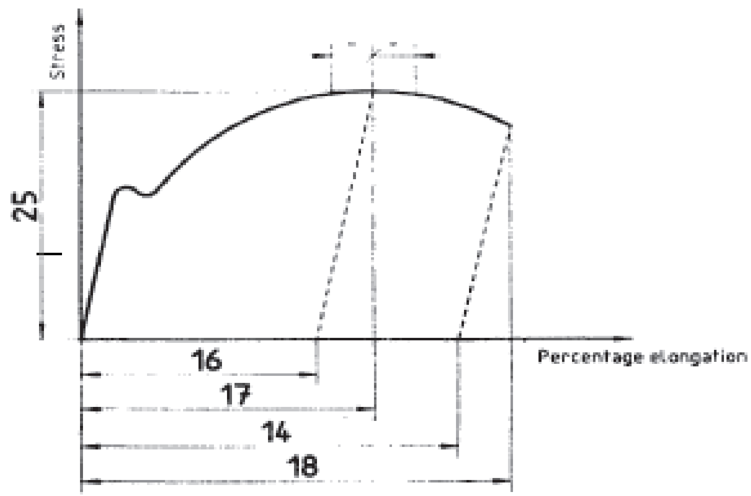
In the absence of sufficient data on all types of materials it is not possible, at present, to fix values of accuracy for the different properties measured by the tensile test.

Annex J provides a guideline for the determination of uncertainty related to metrological parameters.

Annex K provides values obtained from interlaboratory tests on a group of steels and aluminum alloy.

Test report The test report shall contain at least the following information::

- Reference to this International Standard, the. ISO 6892;
- identification of the test piece;
- specified material, if known;
- type of test piece;
- location and direction of sampling of test pieces;
- Measured properties and results.
- IS 1608: 2005



NOTE — See table 1 for explanation of reference numbers.

Figure 1 — Definitions of elongation

- **Shape of the test piece**

Generally the test piece has gripped ends which are wider than the parallel length. The parallel length *(Lc)* shall be connected to the ends by means of transition curves with a radius of at least 20 mm. The width of these ends shall be at least 20 mm and not more than 40 mm. By agreement, the test piece may also consist of a strip with parallel sides. For products of width equal to or less than 20 mm, the width of the test. Piece may be the same as that of the product.

- **Dimensions of the test piece**

The parallel length shall not be less than *Lo* + !!... In case of dispute, the length *La* + *2b* shall always be used unless there is insufficient material. In the case of parallel side test pieces less than 20 mm wide, and unless otherwise specified in .the product standard, the original gauge length *(La)* shall be equal to 50 mm. For this type of test piece, the free length between the grips shall be equal to *La* + *3b.*

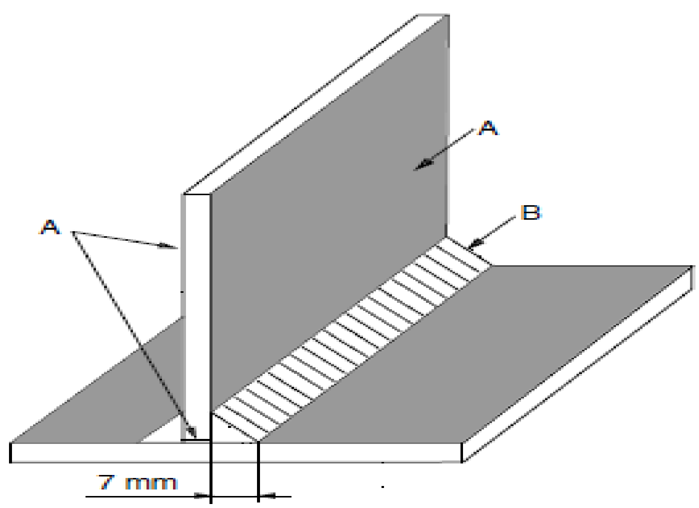
- There are two types of non-proportional test pieces, wit~ dimensions as given in table A.1. When measuring the dimensions of each test piece, the tolerances on shape given in table A.2 shall apply.

Table A.1 — Dimensions of test pieces

Dimensions in millimetres

Test piece type	Width b	Original gauge length L_o	Parallel length L_c	Free length between the grips for parallel sided test piece
1	12,5 ± 1	50	75	87,5
2	20 ± 1	80	120	140

Figure 1 : Typical T welded sample



A : Surfaces coated with the shop primer
B : Weld bead

1.2 Test requirements

- The test sample is to be fractured by suitable means in order to locate the fracture in the throat of the fillet weld.
- Visual examination is to be carried out consisting of checking the external and fractured surface to determine weld penetration and presence of worm-holes, pores and other defects.

1.3 Type and dimension of test samples

- Test samples consist of double fillet welded T-joints formed by plates of the following dimensions:• 300 mm x 120 mm x 15 mm for manual welding and semiautomatic bare wire and flux cored arc welding with gas shielding

Number of samples required

Two samples for each process are to be welded:

- manual metal arc welding with covered electrode of diameter 4 mm
- flux-cored wire metal arc welding with wire of diameter1,2 mm
- solid wire metal arc welding with wire of diameter1,2 mm.

Preparation of test samples

- The shop primer is to be applied in compliance with the manufacturer's specifications. The shop primer thickness (measure made on dry coat) of the test samples is to be at least 30% greater than the maximum foreseen in normal use.

- The pieces are to be tack welded such as to form a Twit adherent contact between the surfaces, without gap.

- For each test a), b) and c) described in [3.4.1], one sample into be welded in horizontal-vertical position (PB), and the other in vertical upwards position (PF), using electrodes of diameter 4 mm and wire of diameter 1,2 mm. Welding is to be made in accordance with Welding Procedure Specification(WPS). The fillet weld is to be deposited in one bead having dimension not exceeding 7 mm x 7 mm as shown in Fig 1.

- Possible defects located within 10 mm from the ends of the weld are disregarded. Lack of penetration having total length not exceeding 1/4 of the weld length is accepted.
- Wormholes and pores having diameter not exceeding 3mmare generally acceptable where the total area of porosity isnot higher than 5% of the fracture section area

- **Re-tests**

Where tests on one sample fail, re-tests on two samples for the same welding process are admitted. Both test samples are to provide satisfactory results. Failing this, the shop primer is not approved

- **Certification**

Subject to the satisfactory outcome of the required checks and tests, the Society will issue to the Manufacture or supplier concerned the approval certificate for the shop primer.

- **Special requirements**

In the case of applications involving the storage and transport of liquefied gases, the appropriate requirements of the Society's Rules for the Classification of Steel Ships also apply

- **Approval of welding procedure specification**

The qualification tests when required, welding of test pieces according to the proposed pWPS and testing of test specimens are to be witnessed by the Surveyor. Upon satisfactory completion of the tests, the Society may approve the WPS as a welding procedure specification.

In its final version, the welding procedure specification (WPS) is to include all the parameters characterizing the welding process; in particular, as applicable:

- type of welding process and equipment, as appropriate
- type of joint, preparation and backing material, if any
- base metal and thickness range filler metal
- welding position
- minimum preheat, minimum and maximum interpose Temperature post-weld heat treatment if applicable
- shielding gas as applicable
- welding parameters

Other information relevant to the welding techniques as Applicable

1 General

Visual, dimensional and, as appropriate, non-destructive examinations are to be performed by the manufacturer on the materials supplied prior to delivery, as required. the general provisions indicated specific requirements for the various products as specified in the relevant Articles of this Section apply. On-destructive examinations may be required by the Surveyor When deemed necessary.

- Thickness tolerances of steel plates and wide flats the tolerances on thickness of a given product are defined as:
- minus tolerance is the lower limit of the acceptable range below the nominal thickness
- Plus tolerance is the upper limit of the acceptable range above the nominal thickness. The requirements for minus tolerances on nominal thickness are indicated in the Articles relevant to the various products. The plus tolerance on nominal thickness is to be in accordance with a recognized national or international standard.
- The tolerances on nominal thickness are not applicable to areas repaired by grinding which are to be in accordance with the relevant requirement for the product.

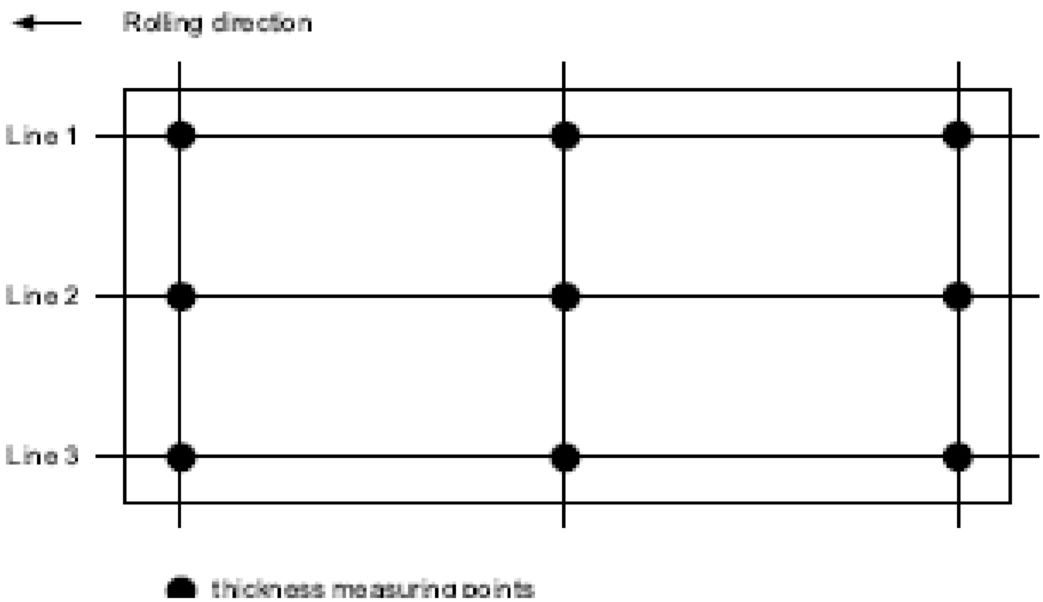
- The responsibility for verification and maintenance of the production within the required tolerances rests with the manufacturer. The Surveyor may require witnessing some measurements.

- **Thickness measurements**

  Automated method or manual method is applied to the Thickness measurements At least two lines among Line 1, Line 2 or Line 3 as shown in Fig 1, are to be selected for the thickness measurements and at least three points on each selected line as shown in Fig 1 are to be selected for thickness measurement.

  If more than three points are taken on each line the number o

Figure 1 : Locations of thickness measuring points



Self-Check- 1	Choose Test

Direction-Choose the best answer

1. The following information and supporting documentation, as applicable, are to be submitted:

A. type designation, product name
B. product description
C. product specification
D. All,

2. Percentage reduction of area shall be determined in accordance with the definition

A. Shape of the test piece
B. Determination of percentage
C. Dimensions of the test
D. None

3. The diftere.tce between the area (Su) and the original cross-sectional area *(So)* expressed as a percentage of the original area.

A. Test results accuracy
B. percentage reduction of area
C. Approval test results
D.None

- ***Note:*** **Satisfactory rating –7points** **Unsatisfactory - below 7 points**
- You can ask you teacher for the copy of the correct answers
- **Answer Sheet**

Score = ____________

Rating:

Name: ___________________________ Date: ________________

Short Answer Questions

an ask you teacher for the copy of the correct answers.

Information sheet-3	Recording and reporting appropriate Materials Safety Data Sheets (MSDS

1.1 Introduction to Material Safety Data Sheet

A material safety data sheet is a technical document which provides detailed and comprehensive information on a controlled product related to:

- health effects of exposure to the product
- hazard evaluation related to the product's handling, storage or use
- measure to protect workers at risk of exposure
- Emergency procedures.

The data sheet may be written, printed or otherwise expressed, and must meet the availability, design and content requirements of WHMIS legislation. The legislation provides for flexibility of design and wording but requires that a minimum number of categories of information be completed and that all hazardous ingredients meeting certain criteria be listed subject to exemptions granted under the Hazardous Materials

1.2 The Purpose of the Data Sheet

The data sheet is the second element of the WHMIS information delivery system and is intended to supplement the alert information provided on labels. The third element of the system is the education of employees in hazard information on controlled products, including instruction in the content and significance of information on the MSDS.

- **Material Safety Data Sheet Content**

A supplier material safety data sheet must provide at least nine categories or sections of content and approximately sixty items of information distributed among those categories. An MSDS must be reviewed at least every three years. The categories must have the following similar headings:

Hazardous Ingredients

- The chemical names and concentrations concerning the hazardous ingredients
- The LD 50 and LC50 indicate the short term toxic potential

- CAS number which is useful in locating more information especially if the product is known by numerous names\

.Preparation Information

- The name address and telephone number of who prepared the MSD
- The date the MSDS was prepared
- If more than three years old, it must be updated

Product Information

- Identifies the product by the name on the supplier label
- Provides the chemical name, family and formula (including molecular weight)
- Lists the product identifiers, manufacturer and supplier names, addresses and emergency telephone numbers

.Physical Data

- The state it is in e.g. liquid
- The odor and appearance of the product
- The specific gravity, vapors density, evaporation rate, boiling point and the freezing point
- The vapors pressure, the higher the concentration the higher the possible air concentration
- The dour threshold, which is the lowest airborne concentration of a chemical that can be perceived by smell
- The pH reflecting the corrosive or irritant nature of the product

Fire and Explosion Hazard

- The temperature and conditions that can cause the chemical to catch fire or explode
- Means of extinction including the type of fire extinguisher required
- Personal Protective Equipment required for fire fighting

Reactivity Data:

- The chemical stability of the product and its reactions to light, heat, moisture, shock and incompatible materials
- Storage requirements based on the reactivity or instability of the product
- Incompatible products that must not be mixed or stored near each other
- The need for disposal before they become extremely reactive

Toxicology Properties:

- The harmful effects of exposure
- How the product is likely to enter the body and what effects it has on the organs in the body
- The short-term (acute) and long-term (chronic) health effects from exposure to the product
- The exposure limits, which indicates the maximum concentration in air of a hazardous substance (gas, vapor, dust, mist, fume) to which nearly all workers (without personal protective equipment) can be repeatedly exposed without adverse health effects. Exposure limits are expressed in thre

Preventative Measures:

- Instruction for the safe use, handling and storage of the product
- The personal protective equipment or safety devices required
- The steps for cleaning up spills
- Information on the waste disposal requirements

First Aid Measures:

- Specific first aid measures related to acute effects of exposure to the product
- First aid steps in the correct sequence
- Information to assist in planning for emergencies

The MSDS may contain additional sections providing further information related to the specific product.

- Hard copy readily available
- Computer terminals
- Employees and others must know where the MSDS is and how to use them

Responsibilities Related to the MSDS

- Develop or obtain a MSDS for each controlled product imported or sold for use in a workplace
- Ensure the MSDS for the controlled product:
- Discloses information that is current at the time of sale or importation of the product

- was prepared and dated not more than three years before the date of sale or importation
- Is available in both official languages
- Ensure the purchaser of the controlled product has a copy of the current MSDS at the time of or prior to the purchaser receiving the controlled product
- Make available any information that is considered confidential (trade secret) information and therefore exempt from disclosure to any physician or nurse who requests that information for the purpose or making a medical diagnosis or providing medical treatment

SECTION 1:	**IDENTIFICATION OF THE SUBSTANCE/ MIXTURE AND OF THE COMPANY INFORMATION**
1.1 Company Name:	**Radnor Products**
1.2 Corporate Address:	259 North Radnor - Chester Road Suite 100 Radnor, PA, 19087-5283
1.3 Manufacturing Address:	259 North Radnor - Chester Road Suite 100 Radnor, PA, 19087-5283
1.4 Phone No.:	
1.5 Fax No.:	
1.6 Emergency Phone No.:	866-734-3438
1.7 Safety Data Sheet (SDS) No.:	R901
1.8 Product Name and Specification:	Stainless Steel in wire form, according to AWS standards AWS Specification SFA-5.9/SFA-5.9M
1.9 Other means of Classification:	64001461, 64001463, 64001465, 64001551, 64001547, 64001549, 64001583, 64001585, 64001587

Self-Check- 3	Choose test

Direction-Choose the best answer

1. Technical document which provides detailed and comprehensive information on a controlled product related to:

A. Material safety data sheet C.Reactivity data

B. Physical Data D. Non

2. The name addresses and telephone number of who prepared the MSD

A. Preparation Information C.Physical Data
B. Product Information D.None

3. The MSDS may contain additional sections providing further information related to the specific product.

A. Hard copy readily available C. Employees and others
B. Computer terminals D. All

- ***Note:*** **Satisfactory rating –7points** **Unsatisfactory - below 7 points**

You can ask you teacher for the copy of the correct answers

- **Answer Sheet**

Score = ___________

Rating:

Name: _________________________ Date: _______________

Short Answer Questions

an ask you teacher for the copy of the correct answers.

,

information sheet-4	Observation of OHS measures

1.1 Introduction to occupational health and safety

Occupational health and safety is one of the most important aspects of human concern. It aims an adaptation of working environment to workers for the promotion and maintenance of the highest degree of physical, mental and social well being of workers in all occupations.

The question of occupational health and safety, as a global issue, is now taking a new turn. The main contributory factors towards this idiosyncrasy seem to be due to the rapid industrial and agricultural development that are taking place in the developing countries, and the emergence of new products and product processes from these

1.2 Definition of Terms

According to WHO (1995), occupational safety and health can be defined as a multidisciplinary activity aiming at:

- Protection and promotion of the health of workers by eliminating occupational factors and conditions hazardous to health and safety at work
- Enhancement of physical, mental and social well-being of workers and support for the development and maintenance of their working capacity, as well as professional and social development at work
- Development and promotion of sustainable work environments and work organizations

1.3 General health and safety

- .good housekeeping good housekeeping, especially the removal of combustible materials, is essential.
- Gas If you can smell gas – don't light any gas torches or use electric welding equipment, but don't rely wholly on your sense of smell to warn you..eye protection
- Wear eye protection and cover bare skin. Be aware that: arc flash can occur through the side of the eye
- arc flash can cause 'sunburn' on exposed skin.

- .hot surfaces mark hot surfaces as such. Better still, assume everything is hot

Health and Safety for Welding

Health and safety issues associated with welding related activities:

- Grinding and material removal
- Safe disposal of waste
- Workshop layout such as:
- Obstacles in the workshop
- Noise or heavy noise areas (muffling or distancing?)
- Hot Metal fragments or work pieces & safe places to put them

Personal Protective Equipment (PPE)

- Protection of others from Hazards
- Hot Materials
- Sparks
- Falling Objects
- Heat
- Burns
- Safe Start-up and shutdown procedures

Description of first aid measures

- **Dust Skin contact:**

Immediately remove any metal fragments or pieces that get under the skin. Wash well with plenty of soap and water following any contact with metal particles. Remove any contaminated clothing and launder before reuse. Seek medical attention if irritation develops.

- **Eye contact:**

Avoid getting finely divided particles in the eyes. Flush immediately with plenty of luke-warm water, keeping eyelids open. Seek medical attention if symptoms persist.

- **Ingestion**:

Welding electrodes are not hazardous, but should be kept out of the mouth. Finely divided particles may be easily ingested along with food, drink or smoking. If large quantities ingested, seek medical advice., fumes SECTION 6: Accidental release measures

- **Environmental precautions**

Do not allow to enter sewers/ surface or ground water. Collect powder using a vacuum cleaner or by gentle sweeping to keep dust away from drains, surface and ground water. Prevent particulates from entering watercourses or drains. Avoid formation of dust clouds.

Figure 2-2. Pesticides are dangerous wherever used.

The discipline covers the following key components:

- the availability of occupational health and safety regulations at workplace
- the availability of active and functional occupational health and safety committee at workplace
- monitoring and control of factory hazards to health
- supervision and monitoring of hygiene and sanitary facilities for health and welfare of the workers
- . inspection of health safety of protective devices
- . pre-employment, periodical and special health examination.
- performance of adaptation of work to man
- provision of First Aid
- health education and safety training to the worker
- Advice to employers on the above mentioned items
- Reporting of occupational deaths, diseases, injuries, disabilities ,hazards and their related preventive measures at working

Self-Check- 4	Choose Test

Direction-Choose the best answer

1. Sweeping to keep dust away from drains, surface and ground water

A. Environmental precautions

B. Ingestion

C. Eye contact

D.None

2. Health and safety issues associated with welding related activities

A. Safe disposal of waste
B. Workshop layout such as:
C. Grinding and material removal

D.None

3. Which is not personal Protective Equipment (PPE)

A. Sparks

B. Heat

C. hot Materials

D. none

- *Note:* Satisfactory rating –7points Unsatisfactory - below 7 points

You can ask you teacher for the copy of the correct answers

- Answer Sheet

Score = ____________
Rating:

Name: ____________________________ Date: ________________

Short Answer Questions

an ask you teacher for the copy of the correct answe

Operation Sheet 1	Interpreting instructions and specifications

The purpose of this operation is to give trainees experience in measuring various Strength parameters of different metals materials.

Interpreting instructions and specifications

Step 1- wear PPE.

Step 2- Reference to this International Standard, the. ISO 6892;

Step 3 - Identification of the test piece;

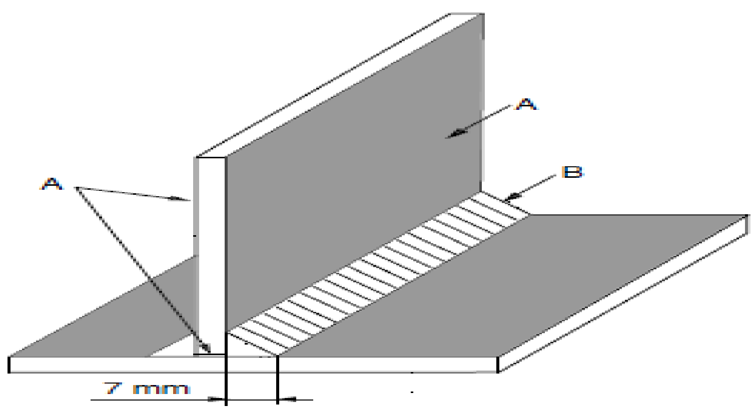
Step 4- Specified material, if known;

Step 5- Type of test piece;

Step 6- Location and direction of sampling of test pieces;

Step 7-Measured properties and results.

Figure 1 : Typical T welded sample



A : Surfaces coated with the shop primer

B : Weld bead

LAP Test	Practical Demonstration

Name: ______________________________ Date: ________________

Time started: ___2:00_am _______________ Time finished: ___4:00_____________

Instructions: Given necessary templates, tools and materials you are required to perform to make simple split pattern in the following tasks within 2hour.

Task 1 Perform to PPE.

Task 2 Perform required pattern material.

Task 3 Perform Reference to this International Standard, the. ISO 6892nt

Task 4 Perform - Identification of the test piece;

Task 5 Perform Specified material, if known;

Task 6 Perform Type of test piece;

Task 7 Perform Location and direction of sampling of test pieces

Step 8 Perform Measured properties and results.

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